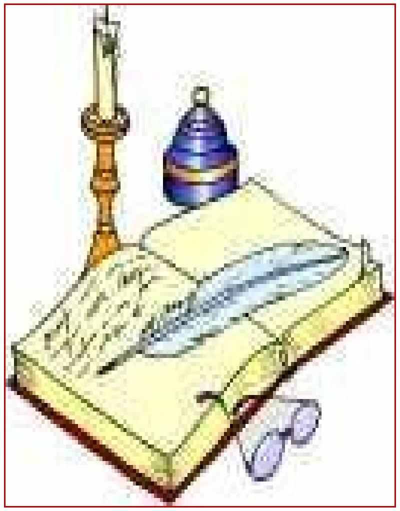

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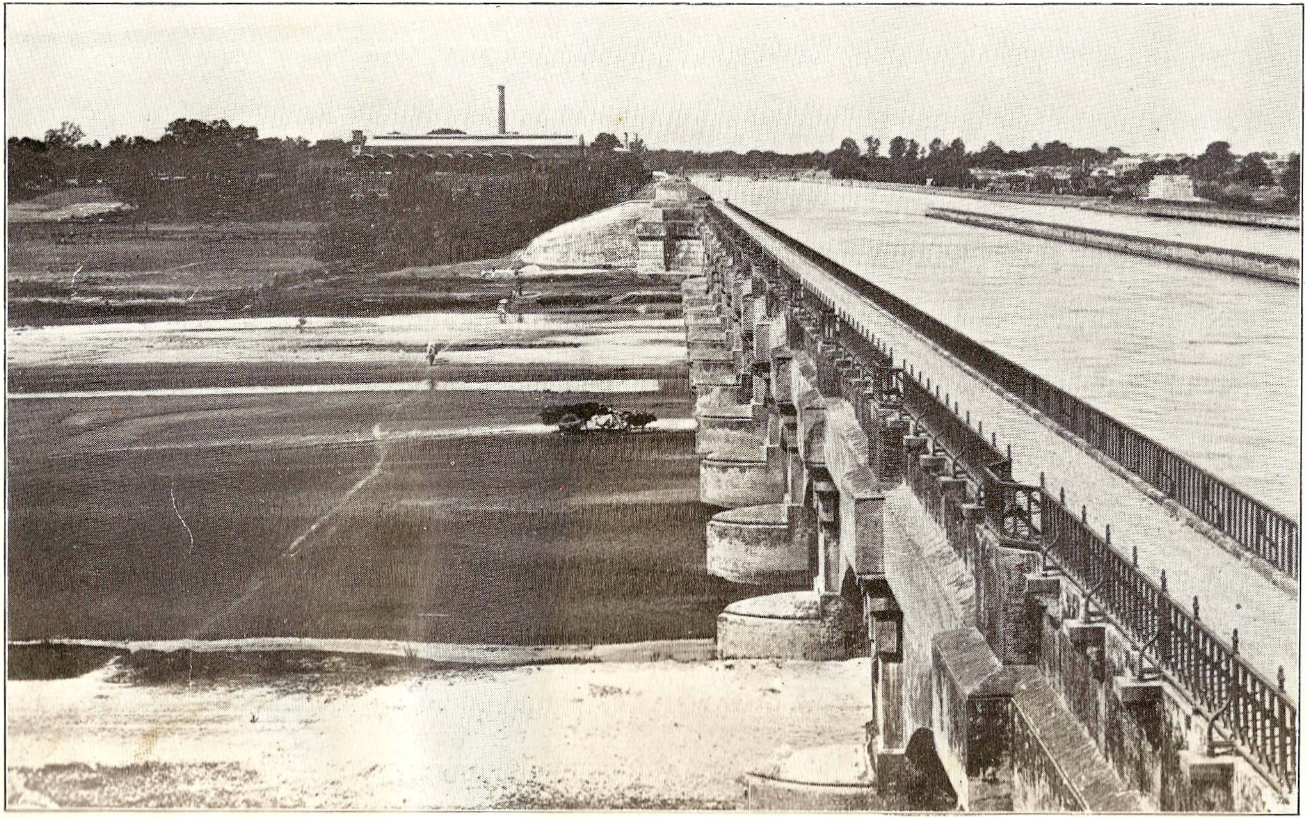

SOLANI AQUEDUCT, GANGES CANAL.

P-1/2

THE MILITARY ENGINEER IN INDIA.

BY

LIEUT.-COLONEL E. W. C. SANDES,

D.S.O., M.C., R.E. (*Ret.*),

LATE PRINCIPAL, THOMASON CIVIL ENGINEERING COLLEGE, ROORKEE, INDIA

AND AUTHOR OF

"IN KUT AND CAPTIVITY" AND "TALES OF TURKEY."

VOLUME II.

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To My Comrades

of

The Corps

of

Royal Engineers.

PREFACE TO VOLUME II

THE publication, in September, 1933, of the first volume of this work, dealing with the achievements of the military engineers of India in fortification and war from 1640 to the present day, left me free to undertake the remaining task of recording the services of these men while working as engineers, scientists and administrators under the civil Government. That record has now been completed, and it demonstrates clearly the extent to which India is indebted to the three Engineer Corps of the East India Company's Armies, and subsequently to the Corps of Royal Engineers, for their civilian labours. The use of the chronological method, followed generally in Volume I, has not been possible in Volume II; for whereas the forty campaigns of the first volume could be formed into a consecutive narrative, the dozen branches of civil employment, which appear in the present volume, have needed separate treatment. The work of excavating a canal has nothing in common with governing a Province: the minting of money has no connection with the education of Indian youth. Accordingly, it has been necessary to pass from one branch of civil engineering to another, and then from civil engineering to allied professions. In so doing I have been compelled to imagine myself in turn an irrigation engineer, a constructor of dams and hydro-electric installations, a road engineer, an architect, a railway engineer, a designer of steel and masonry bridges, a builder of docks and lighthouses, a scientific surveyor and explorer, a student of archæology and geology, a layer of telegraphs, the head of a mint, a political officer, a financial adviser, and a professor! Awaiting my shy and hesitating appearance in each new character was a group of critical and experienced experts; yet they were there to help and not to rend me, and it is through their good offices alone that I have been able to reach the end of an arduous journey through a maze of engineering wonders.

So many officers of the Royal Engineers have assisted me in the collection of the varied information necessary for this volume that I can do no more than offer to all my grateful thanks for their willing help. In particular, however, I desire to acknowledge the assistance of Major-Generals A. C. de L. Joly de Lotbinière, C.B., C.S.I., C.I.E., Sir Sydney D'A. Crookshank, K.C.M.G., C.B., C.I.E., D.S.O., M.V.O., and G. H. Addison, C.B., C.M.G., D.S.O., Engineer-in-Chief, Army Headquarters, India; Brig.-General Sir William D. Waghorn, C.B., C.M.G.; Colonels Sir Sidney G. Burrard, Bart., K.C.S.I., F.R.S., Sir Gerald P. Lenox-Conyngham, F.R.S., Sir Buchanan Scott, K.C.I.E., Sir Gordon R. Hearn, C.I.E., D.S.O., Sir George H. Willis, C.I.E., M.V.O., Sir Charles F. Close, K.B.E., C.B., C.M.G., F.R.S., H. E. S. Abbott,

C.B.E., D.S.O., W. M. Ellis, C.I.E., S. L. Craster, C.B., C.I.E., H. E. C. Cowie, C.B.E., D.S.O., H. de L. Pollard-Lowsley, C.M.G., C.I.E., E. T. Rich, C.I.E., H. A. D. Fraser, C.B., H. M. Jackson, M. N. Macleod, D.S.O., M.C., and M. Stagg, O.B.E.; Lieut.-Colonels L. E. Hopkins, D.S.O., O.B.E., and A. S. Holme, O.B.E.; Majors A. D. G. Shelley and D. Fitz J. Fitzmaurice, and Captain R. B. Emerson.

Brig.-General Sir James E. Edmonds, C.B., C.M.G., late R.E., and Sir William Foster, C.I.E., have kindly read the typescript, chapter by chapter; and Sir Thomas Ward, K.C.I.E., M.V.O., Sir Evan Cotton, C.I.E., Sir Frederick Cunningham, K.C.I.E., and Brig.-General Sir Percy M. Sykes, K.C.I.E., C.B., C.M.G., have given me valuable information and advice. Through the death, in April, 1934, of Lieut.-Colonel P. H. Kealy, R.E. (retd.), Secretary of the Institution of Royal Engineers, I lost an indefatigable helper. His knowledge of the history of his Corps was remarkable both for its extent and accuracy. The duties connected with the publication of this volume, since Colonel Kealy's death, have been ably performed by his successor, Lieut.-Colonel E. V. Binney, D.S.O., R.E. (retd.). My acknowledgments are due also to Mr. J. G. Scott, the Librarian of the Corps Library in Whitehall, Mr. J. Hurwitz, Chief Clerk of the Institution of Royal Engineers and to the officials of the India Office Library and Records Department.

The system adopted for the spelling of names is that of the *Imperial Gazetteer of India*, this being more widely known than the "Hunterian System." As the sources of information are given in footnotes, a bibliography has not been included. Sketch maps of India and Burma (duplicates of those in Volume I) will be found in a pocket at the end of this volume.

During the course of twenty-eight years' service in India I learnt something of her nature. I explored her mountains and plains, enjoyed her unrivalled sport, visited her ancient cities, experienced her extremes of climate, fought alongside her sons in war and worked with them from end to end of the peninsula. In June, 1929, I was invited to compile the history of my Corps in India, and then began to collect the necessary information. Proceeding to England, in the following spring, on leave pending retirement, I commenced the writing of Volume I in June, 1930; and now, after more than four years of continuous effort, I have finished my task. My aim has been to show not only the achievements of the Royal and East India Company's engineers in India, but the steady advancement of that country towards the prosperity and distinction which she has now attained under British rule and guidance. If that end has been secured I can lay down my pen with satisfaction, and so make my farewell bow to India.

E. W. C. SANDES.

19th August, 1934.

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THE MILITARY ENGINEER IN INDIA

VOL. II

CHAPTER I.

IRRIGATION IN NORTHERN INDIA.

AN Australian, when reviewing a book on water, delivered himself of the aphorism that it was a dry book on a dry subject. Perhaps he was right. If the volume was a treatise on hydraulics, his description would meet, no doubt, with the approval of the general public. But there are many aspects of water; and the story of the development of irrigation in India, shorn of statistics and formulæ, has a peculiar interest. It is arresting because it deals with work undertaken not merely for profit but for the welfare of millions of impoverished people. Irrigation in India as a whole has certainly been profitable: but it has also been, in a higher degree, humanitarian.

In 1568, long before a British engineer dug a canal in the vast plains of Hindustan, the Mughal Emperor Akbar wrote[1]:—" In acknowledging God's mercy in establishing this great Empire, my desire, purer than water, is to supply the wants of the poor, and to leave permanent marks of the greatness of my Empire by digging canals and founding cities, by which too the revenues of the Empire will be increased. For God has said, from water all things are made. I consequently ordain that this jungle, in which subsistence is obtained with thirst, be converted into a place of comfort, free from that evil." But Akbar was not the first of the Muhammadan rulers to recognize the blessings conferred by irrigation. Between the years 1351 and 1388, the Emperor Firoz Shah Tughlak excavated a canal, 150 miles in length, on the right bank of the River Jumna to water his favourite hunting-ground at Hissar,[2] where one of his nobles, who had voyaged overseas, erected a peculiar building to give his master an idea of a ship.[3] This canal silted up, but it was

[1] *Journal of the Asiatic Society of Bengal*, Vol. XV, 1846, pp. 213–215.
[2] About 100 miles north-west of Delhi. The present Hansi Branch of the Western Jumna Canal follows this line.
[3] *Ways and Works in India*, by G. W. MacGeorge, p. 126.

reopened by Akbar when he issued his proclamation, and made wider and deeper than before. Trees of every description were planted along its banks "to make it like the canal under the tree of Paradise."

The Emperor Shah Jahan, in his turn, became an enthusiast in canal work. He had a capable engineer in Ali Mardan Khan, a noble of his court, who in 1626 added a branch canal leading from Firoz Shah's canal to Delhi, designed to supply water to the emperor's palace and gardens and to the city. Seven years later, Shah Jahan caused the Hasli Canal to be dug in the Bari Doab[1] to bring water to the fountains of the royal gardens at Lahore. Other canals were excavated in the region of the Jumna and in the Punjab, but all fell gradually into disuse with the collapse of the Mughal Dynasty. Although they irrigated certain tracts, they seem to have been made more for the glorification of kings than the protection of the poor. Yet they benefited posterity, for when the British engineers turned their attention to irrigation in Northern India, they began their great task by adapting and improving the ancient systems which they found, and in so doing learned the elements of an almost unknown science.

Huge tracts of Northern India are now covered by a network of canals. At their heads, some of these artificial rivers are as large as the Thames in flood. They throw out branches; the branches send out distributaries; the distributaries supply minor channels; and these in turn feed small watercourses from which the life-giving liquid is led on to the thirsty soil, turning a desert almost into a garden, raising the value of the land, spreading and enriching the population, protecting it against famine, and at the same time bringing a stream of money into the Government treasuries. It is not too much to say that the irrigation of Northern India is one of the greatest humanitarian works ever performed; and the men who initiated it, who evolved its elementary principles, who faced its early failures, who extended it between war and war, and who handed over to their civilian successors a system which these have elaborated to its present perfection, were the military engineers of India.

Before the Mutiny, the duties of the military engineers of India were rather civil than military. These officers marched only occasionally to war, and, the fighting ended, most of them returned at once to their civil work. When the Public Works Department was organized in 1854, there was a stupendous amount of civil engineering to be done, and very few civil engineers to do it, so the burden fell on the military engineers. The demands of civil engineering increased and multiplied after the Mutiny, and the Department was

[1] *Doab.* A tract between two rivers. The Bari Doab is the name given to the tract between the Sutlej and Ravi Rivers in the Punjab.

divided in 1866 into a Military Works branch, a Civil Works branch including irrigation, and a Railways branch. Junior civil engineers were then flocking in, and replacing the soldiers in the civil branches. By 1895, however, the Military Works Department had been separated from the Public Works Department, which then became purely civilian in nature ; but even so, most of the Chief Engineers in India on the civil side were still military. Thereafter the tide of civil engineers, experts and specialists, rose and rose in volume until, at the present day, there is hardly a military engineer in civil employment other than on the railways, or in the Survey of India or the Mints.[1] Hence this sketch of the irrigation work of military engineers is concerned chiefly with the nineteenth century, when the great network of canals which now reaches across India was beginning to extend over the land ; it is not a history of the development of irrigation, but a study of the part taken in that process by a few outstanding men.

A committee which assembled in India in 1888[2] placed on record the advantages of employing military engineers on civil work. "What a Royal Engineer most needs," they wrote, "to make him as efficient as possible in time of war, is a knowledge of the resources of the country, the habit of dealing with natives, and experience in understanding what they can and what they cannot be expected to do, resourcefulness in adapting means to ends, and practice in contending with unforeseen difficulties. The training obtained in carrying out large railway or irrigation works is, in our opinion, that in which Royal Engineers are most likely to gain the experience which will make them useful and efficient with an army in the field." These opinions were based, no doubt, on the achievements of the military engineers who were recalled from civil employment during the Afghan, Sikh and Burma Wars and in the Indian Mutiny. The means by which they gained some of their experience are dealt with in this chapter.

The first move of the British Government in India towards irrigating the desert areas of the north took place in 1817, when Captain George Rodney Blane, of the Bengal Engineers, was appointed to restore Shah Jahan's branch canal to Delhi. Three years later, after a closure of sixty-seven years, canal water reached the Imperial City once more ; but Blane did not live to see the full benefit of his work, for he died of malaria at Ludhiana in 1821. A monument at that place records that he was beloved and esteemed, and that his premature death excited universal regret. It is said that, even in his short

[1] In January, 1933, there was one R.E. officer in civil employment (Irrigation) in Burma, one in the Punjab (Hydro-Electric), one in the United Provinces (Buildings and Roads), and one at Aden. Twenty-nine R.E. officers were then employed on the Indian railways, twenty-five in the Survey of India, and three in the Mints and the Security Printing Press.

[2] Lyall Committee Report, 1888, pp. 20–21.

career, Blane prepared plans for many of the works afterwards built by the celebrated Captain John Colvin[1] of the same Corps, who has been called the "Father of Irrigation in Northern India." Colvin succeeded Blane and spent the greater part of his life in enlarging and extending the canals of this area. The restoration of Firoz Shah's original canal to Hissar was begun in 1823, and during the next twenty years the system known as the Western Jumna Canals was fully developed. "Colvin was well remembered in my time in 1890," writes Sir Thomas Ward,[2] "and the oldest of the villagers used to talk of '*Kolpeen Sahib Bahadur. Jis ne yih nahr banaiya*' (who made this canal). In 1910, being then on tour at the tail of the Hansi Branch, which was laid out and built by Colvin himself, I met a man in a village on the borders of Bikaner who had been his orderly from the start of this work. He was full of enthusiasm for his master, and told me that in those days the engineer was accompanied on his work by a troop of Skinner's Horse." Colvin had, as one of his assistants, Lieutenant A. D. Turnbull, B.E.[3] (Bengal Engineers), a most energetic worker, and also Lieutenants W. E. Baker,[4] Robert Napier[5] and H. M. Durand,[6] Bengal Engineers, and a young Lieutenant of the Bengal Artillery named P. T. Cautley, about whom more will be written.

Blane, Colvin and the others who constructed the Western Jumna Canal system, had no previous experience in irrigation engineering, and no text-books other than those on irrigation in Italy, where the conditions were very different. Consequently, they made serious mistakes. They gave too steep a slope to the channels so that rapids formed and threatened to destroy the masonry works. Their alignments were not of the best. Some areas were given too much water, whilst others were starved. The natural drainage of the country was often obstructed to such an extent that water-logging occurred, bringing to the surface a salt (*reh*) which destroyed the crops, and causing malarial swamps. The same evils were even more marked in the Eastern Jumna Canal, which, starting from the Jumna opposite the head of the Western Canal, tails into the river at Delhi. After this canal was opened in 1830, an extensive realignment was necessary to enable it to work, in addition to the introduction of masonry falls at intervals to reduce the slope.[7] But these two canal systems

[1] A biography of Colonel John Colvin, C.B., appears in *Biographical Notices of Officers of the Royal (Bengal) Engineers*, by Colonel Sir E. T. Thackeray, V.C., R.E., pp. 33–35.

[2] Extract from notes supplied to the author by Sir Thomas Ward, C.I.E., M.V.O., in January, 1933. Sir Thomas Ward entered the P.W.D. in 1883 and served with distinction in India, Siam, Mesopotamia and other countries. He became Inspector-General of Irrigation in India in 1917.

[3] Colonel A. D. Turnbull died in Landaur in 1864.

[4] Afterwards General Sir William Baker, K.C.B., who is alluded to later.

[5] Afterwards Lord Napier of Magdala, G.C.B., G.C.S.I.

[6] Afterwards Major-General Sir Henry Durand, K.C.S.I., C.B.

[7] The canal was constructed by Captain Robert Smith, B.E., assisted by Lieut. P. T. Cautley, Bengal Artillery.

taught a few engineers the rudiments of irrigation design. The experience was well bought, for it bore fruit in the magnificent Ganges Canal project. The Upper Ganges Canal is no longer the largest in the world; but the boldness of the project, undertaken as it was by inexperienced men without modern appliances, places it in a class by itself, and, most remarkable of all, the engineer who designed and constructed the canal and all its huge works was an officer of the Bengal Artillery. "The Ganges Canal, Colonel Cautley's monumental work," writes D. G. Harris,[1] "still ranks among the largest in the world, and has served, in many respects, as a model for those which have since been built."

The *doab*, or tract, between the Ganges and the Jumna had always promised to be most fertile if properly watered. One Muhammad Abu Khan knew it and dug a canal about twelve miles in length north-west of Meerut before the British made their appearance; and in 1827, Captain Henry Debude (or De Budé), of the Bengal Engineers, elaborated the scheme, originated by the Indian engineer, to dam up the West Kali Nadi[2] and thus to irrigate some land on the right bank of the Ganges. Debude's project[3] was never carried out, but it may be considered as the germ of the subsequent operations. As time advanced, and the two Jumna Canal systems proved remunerative and beneficial in spite of their many original defects, the Government was encouraged in more ambitious schemes and particularly in Rohilkhand to the east of the Ganges. Major John Colvin, B.E., was sent to report on some projects for the restoration of ancient canals in that district, with the result that a line of canal was dug near Nagina and others followed. Proposals were put forward for small canals in the Dehra Dun, north of Saharanpur; and at about the same period, Captain W. E. Baker, B.E.,[4] "a very active-minded man" as Sir Thomas Ward says, who succeeded Colvin as Superintendent of the Delhi Canals, surveyed the country between the Jumna and Sutlej Rivers and recommended the construction of a canal taking off from the Sutlej. Political difficulties, however, caused Baker's scheme to be shelved.

Debude's enquiries had established the fact that no river other than the Ganges itself could supply sufficient water to irrigate the Ganges-Jumna *doab*, and in 1836 Lieut.-Colonel John Colvin, C.B., B.E., then Superintendent-General of Canals, satisfied himself that a suitable site for the headworks of a canal could be found near Hardwar, where the Ganges enters the plains. Captain P. T. Cautley

[1] *Triennial Review of Irrigation in India*, 1918–21, p. 30. (A Government publication written by Mr. D. G. Harris, C.S.I., C.I.E., I.S.E., when Consulting Engineer to the Government of India.)

[2] A small tributary of the Jumna.

[3] Estimated to cost three lakhs of rupees.

[4] A biography of General Sir William Erskine Baker, K.C.B., is given in *Addiscombe. Its Heroes and Men of Note*, by H. M. Vibart, pp. 415–421. Baker laid the foundation of British irrigation in Sind, then founded the railway system of Bengal, and finally organized the P.W.D. in Northern India.

agreed with him,[1] and after Colvin had left India at the end of the year, Cautley took his first series of levels in the *khadir*[2] near Hardwar. It is possible that the great project would have languished for a time if northern India had not been swept by a disastrous famine in 1837–38. This was one of those frightful and periodical calamities which have caused the death of millions of Indian cultivators and the loss of millions of pounds of revenue. "The project of making a canal from the Ganges," writes Cautley,[3] "was a question to be decided at the earliest possible period. My views were explained to Lord Auckland, then Governor-General, with a recommendation that Government should authorize the disbursement of a few thousand rupees for an examination of the *khadir*. His lordship having approved this measure, I proceeded to Hardwar and commenced operations in the month of December, 1839."

Cautley submitted his first project on May 12th, 1840, and on November 24th, 1841, a committee under Major (afterwards Major-General Sir Frederick) Abbott, B.E., with Cautley and Baker as members, was ordered to proceed to Hardwar to report on the proposed works and the best methods to adopt in executing them. A favourable report having been received on February 25th, 1842, the Government directed that work should begin, so ground was broken at Kankal below Hardwar on April 16th, and brickmaking started at several points along the proposed line. Cautley detached Turnbull from the Eastern Jumna Canal works to commence operations from Roorkee from the twentieth mile onwards, and so well was the whole undertaking planned that by July the two engineers had lined out nearly one hundred miles, collected quantities of materials, and had the excavation in full progress at three points.

Alfred Deakin gives a graphic description of Cautley's great project.[4] "Its colossal character," he says, "can be best conceived when a picture is presented to the mind of an artificial river sometimes carried over what in the rains are rivers, sometimes having those rivers carried over it, and at other times taking them into its course. The first twelve miles of the Ganges Canal are in deep cutting, and at the sixth mile it encounters the Rani Rao torrent, transported overhead in a masonry aqueduct (at Ranipur) termed a superpassage, 200 feet wide and capable of taking a flood 14 feet deep.[5] In the tenth mile comes the Puttri (Pathri) torrent, received by a superpassage 296 feet wide, 14 deep and 450 feet long.[6] The Ratmau torrent in the thirteenth mile offers an equally astounding

[1] *Report of the Ganges Canal Works*, 1854, by Colonel Sir Proby T. Cautley, K.C.B., F.R.S., Vol. I, p. 16. A biography of Sir Proby Cautley is given in *Addiscombe. Its Heroes and Men of Note*, by H. M. Vibart, pp. 333–336.

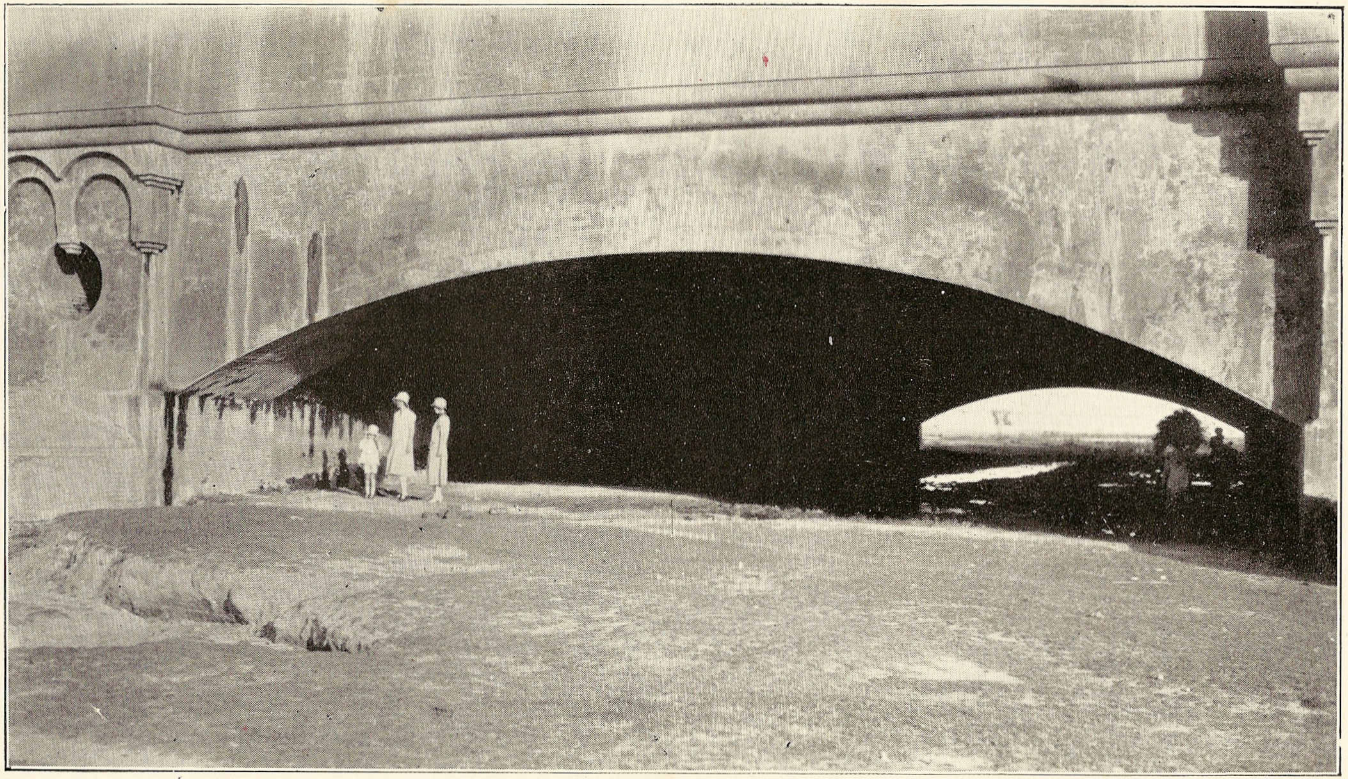
[2] *Khadir* or *Khadar*. Low-lying land near a river.

[3] *Report on the Ganges Canal Works*, 1854, by Colonel Sir Proby T. Cautley, K.C.B., F.R.S., Vol. I, p. 18.

[4] *Irrigated India*, by the Hon. A. Deakin, M.L.A., p. 183.

[5] The Ranipur Superpassage cost £35,000.

[6] The Pathri Superpassage cost £43,000.



ONE ARCH OF THE SOLANI AQUEDUCT.

spectacle. It is permitted to flow straight into the canal.[1] . . . The Solani Aqueduct comes in the nineteenth mile. It has 750 feet in length of clear waterway on 15 arches, or 920 feet of masonry in all, bearing a channel 164 feet broad and 10 feet deep upon foundations 252 feet wide, resting on wells sunk 20 feet below ground. The up- and downstream continuations are carried on an immense earthen embankment whose base is 350 feet wide, making 15,700 feet lined with masonry between banks 30 feet wide—a far grander work than anything in Italy."[2]

Such are the works which Cautley built in the first twenty miles of his canal between Hardwar and Roorkee to attain what is known as the "backbone" (or higher ground) of the country from which he could command the land to be irrigated for hundreds of miles towards Cawnpore. To reach that backbone quickly, he had to carry his canal across the copious natural drainage lines of the country near the Siwalik Hills. A project of such a nature, and on such a scale, had never been undertaken before, nor has it since. The Solani embankment is more than $2\frac{3}{4}$ miles long and 36 feet high, and with its great aqueduct, under which the Solani River pours in times of flood, it may be considered as one of the most magnificent irrigation works ever constructed. The canal was designed originally to carry 6,750 *cusecs* (cubic feet of water per second), but it can carry more than 8,000 *cusecs* when required. The extent of the Upper Ganges Canal system is shown by the fact that it has 568 miles of main canal and branches, and 3,293 miles of distributary channel.

It was not to be expected that the course of such an undertaking would be smooth and easy. War overshadowed India; money was scarce; engineers were few and inexperienced; Government was harassed and sceptical. "Originating as it did during the commencement of the Afghan War," writes Cautley,[3] "the Ganges Canal was nursed at a period of intense trouble to the State; its weary progress was unwillingly prosecuted during the whole of a warlike administration. The early part of the succeeding administration, distinguished as it was by the Sikh invasion and the consequent demand on the public treasuries, was marked by still further interruption to the progress of the canal. It was not until the close of the war that the subject of the Ganges Canal works was allowed again to occupy the attention of the Government." Deeply involved in the First Afghan War, the Government directed on June 21st, 1842, that all the works should be stopped and statements of expenditure submitted; but three months later they relented so far as to allow an annual expenditure of two lakhs of rupees, since the works

[1] The Ratmau torrent works at Dhanauri cost £52,600. In times of flood the canal is closed by the gates of a regulating bridge, and the torrent escapes over a weir.

[2] The Solani aqueduct and embankment cost £328,000 (*A Short Account of the Ganges Canal*, by Major Baird Smith, B.E., 1854).

[3] *Report on the Ganges Canal Works*, 1854, by Colonel Sir Proby T. Cautley, K.C.B., F.R.S., Vol. I, p. 39.

had progressed too far to be stopped altogether. They were assailed by many doubts, and perturbed by the discovery of a mathematical error in the original report. They feared that earthquakes might damage the Solani aqueduct, that the navigation on the River Ganges might be destroyed, and that waterlogging might spread the deadly scourge of malaria. Cautley had designed his canal as an irrigation channel capable of navigation; but in 1843 the Government suddenly decided that it should be primarily a *navigation* canal "and that all the water not required for that purpose should be distributed for irrigation." The main trunk was to be directed on Allahabad instead of Cawnpore in order to connect with the steamer traffic on the Ganges. Was ever an unfortunate engineer faced with a greater dilemma after he had started work? It is hardly necessary to say that the alignment and design of irrigation and navigation canals are governed by altogether different factors. The irrigation canal must traverse culturable areas, avoiding large towns; and its water must flow at a suitable speed. The navigation canal should connect trade centres, and its water should be almost stagnant. The one is the antithesis of the other.

However, the navigation canal scheme was dropped, and in February, 1843, Cautley was joined by Lieutenant R. Strachey,[1] of the Bengal Engineers. Having completed his survey operations, Cautley submitted three alternative projects[2] in February, 1845, and shortly afterwards proceeded on furlough after making over charge to Major W. E. Baker. Strachey was engaged on the canal headworks at Myapur below Hardwar, assisted only by a few untrained subordinates, while Baker and Turnbull had only two civilian assistants and some subordinates to help them on the other works. Then came the First Sikh War, and all three Bengal Engineers hurried to its battlefields while the canal work virtually ceased. It was not till March, 1847, when Lord Hardinge, the Governor-General, visited Hardwar, that a vigorous prosecution of the work was decided upon. The scheme was strongly supported by Mr. James Thomason, the Lieutenant-Governor of the North-West Provinces, who founded the Thomason Civil Engineering College at Roorkee in 1847 on Cautley's suggestion and appointed Lieutenant R. Maclagan, B.E.,[3] as Principal of the college, which was intended primarily for the training

[1] Afterwards Lieut.-General Sir Richard Strachey, G.C.S.I., whose biography appears in *Addiscombe. Its Heroes and Men of Note*, by H. M. Vibart, pp. 490–495. Strachey became Inspector-General of Irrigation in 1866, but achieved greater eminence in Government finance and as a geologist and botanist. His brother, Sir John Strachey, G.C.S.I., I.C.S., was Lieut.-Governor of the North-West Provinces in 1874-76.

[2] Amounting to 92, 87 and 82 lakhs of rupees.

[3] A biography of General Robert Maclagan is given in an article entitled "One of a Remarkable Family," by W. Broadfoot, which appeared in *Blackwood's Magazine*, August, 1894. He was the father of Sir Edward Maclagan, K.C.S.I., K.C.I.E., I.C.S., Governor of the Punjab. Robert Maclagan was Principal of the Thomason College from 1847 to 1860, and Chief Engineer of the Punjab from 1861 till he retired in 1879. He died in 1894. See also Chapter XVIII.

of engineer officers and subordinates for the Ganges Canal work. Large workshops were built also on the right bank of the Solani at Roorkee.

After the First Sikh War, Richard Strachey left the Northern Division of the Ganges Canal, in which are all the great works between Hardwar and Roorkee. Having handed over charge to Lieutenant Henry Yule, B.E., Strachey began those studies in geology and botany in the Himalayas, and even in Tibet, where his brother, Captain Strachey, had been in 1846, which brought him at last the honour of being elected President of the Royal Geographical Society. His successor at Roorkee, Henry Yule, was a most prolific writer and a man of remarkable character. General Collinson describes him as " one of those curious racial compounds, which one finds on the east coast of Scotland, in which the hard Teutonic grit is sweetened by the artistic spirit of the more genial Celt."[1] Yule could be hard to himself as well as to others. He soon became accustomed to the din of the workshops at Roorkee, but the unpunctuality of the native workmen upset his irritable nature. Vexed with himself for losing his temper so often, he decided to impose a rigid self-discipline, and each time he flew into a rage he transferred a fine of two rupees from his right to his left pocket, the accumulation being devoted in the end to the erection of a sundial to teach the workmen the value of time ![2] Yule was colourblind, and when he became Under-Secretary, P.W.D., in Calcutta in 1855 to the very conventional Colonel W. E. Baker as Secretary, he invested in a new pair of trousers. " Not *quite* your usual taste, sir," remonstrated his tailor. But Yule was adamant. He appeared before the official world in brilliant claret-coloured foundations, and when the horrified Baker protested, replied, " Claret colour ! Nonsense, my trousers are silver-grey." And even when convinced of his error, he wore these outrageous garments to the very end. Such was Henry Yule.

But to return to the Ganges Canal. On January 11th, 1848, Cautley having arrived from England and resumed charge, Baker went on furlough after no less than twenty years absence from his native land. By that time an expenditure of over 17 lakhs had been incurred, and Government was fully committed to the completion of the project. Yule left Roorkee in April to take part in the Second Sikh War, and was followed in the Northern (1st) Division of the Ganges Canal by Lieutenant (afterwards Major-General) A. G. Goodwyn, B.E. Lieutenant Edward Fraser had charge of the 2nd Division (to the 110th mile), and other Bengal Engineers employed farther down the line were Lieutenants C. D. Newmarch, C. J. Hodgson[3] and C. W. Hutchinson.[4] Lieutenant F. Whiting, B.E., and

[1] Memoir of Colonel Sir H. Yule, K.C.S.I., C.B., late R.E., by Major-General T. B. Collinson, late R.E., appearing in *The R.E. Journal*, March, 1890.

[2] *A Memoir of Colonel Sir Henry Yule, R.E., C.B., K.C.S.I.*, by A. F. Yule, p. 11.

[3] Afterwards Major-General Charles Hodgson.

[4] Afterwards General Charles Hutchinson, C.B., C.S.I.

Lieutenant Price of the 1st Fusiliers,[1] joined the cadre at a later date, and also Lieutenant R. Baird Smith, B.E.,[2] and there were several civil engineers and many subordinates. The construction of the Solani aqueduct was finished in March, 1854, and on April 8th of that year the Ganges Canal was opened officially by the Lieutenant-Governor of the North-West Provinces.[3] It is said that a body of fanatics refused to believe that the holy water of the Ganges River would consent to enter the canal at Myapur, and formed themselves into a phalanx in the bed of the excavation to emphasize the expected miracle; but the laws of gravity prevailed, and the phalanx fled before the rushing waters.[4]

Cautley's great work was done. "Let me claim honour, high honour," wrote Lord Dalhousie,[5] "for the man whose genius has designed, and whose skill, energy and perseverance have wrought this great work." After a few years the canal proved to be most remunerative, and during the single famine year of 1865–66 it is said to have repaid to the country more than its then total cost. But magnificent as was Cautley's achievement, it is idle to deny that he made serious errors in design. His bed slopes were too great, his masonry falls caused heavy scour in the bed and banks, and the general layout of the distributary system was much inferior to that adopted in modern practice. Other defects and errors were pointed out by Major-General Sir Arthur Cotton, K.C.S.I.,[6] when he inspected the works in 1863 at the request of the Government, and his report led to acrimonious discussion. A very considerable amount of remodelling was necessary before the defects were remedied; but for all that, the general soundness of Cautley's judgment, considering the state of knowledge in his day, was little short of marvellous. He had the advantage of working in the time of that greatest of Indian proconsuls, Lord Dalhousie,[7] who initiated the railways, telegraphs and postal system and supported every development of the country.

"Sir Arthur Cotton," says Mr. Deakin,[8] "when called in to criticize the original plan in 1863, had condemned it almost wholly, and recommended in its stead the construction of a new headwork for a new main canal much lower down the river. Ultimately this proposal of his was adopted in addition to, but not in substitution for,

[1] Designer of the present Thomason College building.

[2] Afterwards Colonel Richard Baird Smith, C.B., who was Chief Engineer in the Siege of Delhi during the Mutiny (see Chapter XVII, Vol. I). Baird Smith served in the Irrigation Department in the North-West Provinces from 1840 to 1857, except during the Sikh Wars.

[3] The Hon. John Russell Colvin.

[4] *Ways and Works in India*, by G. W. MacGeorge, p. 158.

[5] Letter from Lord Dalhousie to the President of the India Board, dated May 13th, 1854.

[6] The eminent irrigation engineer of Southern India whose work is described in Chapter II.

[7] Lord Dalhousie succeeded Lord Hardinge as Governor-General in 1848, and was followed by Lord Canning in 1856.

[8] *Irrigated India*, by the Hon. A. Deakin, p. 179.

COLONEL SIR PROBY T. CAUTLEY, K.C.B., LATE BENGAL ARTILLERY.

The builder of the Ganges Canal.

the existing plan." This project for a "Lower Ganges Canal" was submitted in November, 1870, by Captain W. Jeffreys, B.E., and work on the new line having begun in 1872, the canal was completed in 1880 after many delays. The headworks are at Narora on the Ganges, about 130 miles below Hardwar, and the canal irrigates large districts, lower down the Ganges-Jumna *doab*, which could not be served by the original canal. The two canals are connected, and form, indeed, one system extending from the Siwalik Hills almost to Allahabad and irrigating 2½ million acres.[1] The builder of the Narora headworks was Captain J. H. Western, R.E., who went to Egypt in 1885 and made his reputation there under Colonel Colin Scott-Moncrieff, R.E.[2] Another of Scott-Moncrieff's assistants in Egypt was Mr. (afterwards Sir William) Willcocks,[3] the greatest of all the irrigation engineers who have been born and bred in India, and perhaps in the world. Though easier to build than the Upper Ganges Canal, because it required no superpassages or level-crossings in its first few miles, the Lower Ganges Canal had a chequered career. It suffered a terrible disaster in 1885, when its great aqueduct over the Kali Nadi at Nadrai was destroyed by an unprecedented flood. The structure which replaced this aqueduct in 1889 is probably the largest of its kind, exceeding even the Solani aqueduct in size. Among the military engineers who constructed the Lower Ganges Canal was Colonel W. W. Greathed, C.B., of Indian Mutiny and China fame. He was concerned also in making the Agra Canal, which takes off from the Jumna at Okhla about eight miles below Delhi and irrigates the barren country on the right bank of the river between Delhi and Agra. This canal was designed for navigation as well as irrigation, because it drained so much water from the Jumna during the dry season that boats could not use the river. It was opened in 1874.

Before leaving the United Provinces it may be well to mention that to Richard Strachey, of the Bengal Engineers, belongs the honour of proposing in the year 1855 the construction of the first "protective" canal in India, that is to say, a work undertaken to protect the people against famine and without much likelihood of profit. This was the Betwa Canal, starting near Paricha, some thirteen miles east of Jhansi. Nothing was done until about 1869, 9

[1] There are 7,650 miles of channels in the combined systems.

[2] Afterwards Colonel Sir Colin Scott-Moncrieff, K.C.S.I., K.C.M.G., LL.D., late R.E. A Memoir of Scott-Moncrieff appears in *The R.E. Journal*, Vol. XXVI, July–Dec., 1917, pp. 171–178. After the Indian Mutiny, Moncrieff served on the Western and Eastern Jumna Canals, and in 1869 came to the Upper Ganges Canal, where, for eight years, he remedied faults in design. He retired in 1882, but in 1883 took charge of the irrigation in Egypt, where he restored the Nile Delta Barrage and made his great reputation. He returned to India to preside over the Irrigation Commission of 1901–02, which gave such an impetus to irrigation in all the provinces.

[3] Sir William Willcocks, K.C.M.G., of Egyptian and Mesopotamian fame, died in July, 1932. He was a brother of General Sir James Willcocks, who commanded the Indian Corps in France.

when a project was prepared, and after many delays a further project was sanctioned in 1881 and the canal was opened in 1885. The Betwa system has been followed by the Ken system, opened in 1908, the Ghagar system and others, but it deserves to be mentioned because it was originated as a philanthropic work by a military engineer. The Ganges-Jumna *doab*, now covered with canals, is the most fertile region in India—rich, thickly populated, and secure against famine. To its north, from the region of Bareilly to beyond Lucknow, the modern Sarda Canal system irrigates Oudh;[1] but as military engineers had no part in that achievement, it is outside the scope of this narrative. We turn, accordingly, to the Punjab, where the experience gained on the Jumna and the Ganges was of the utmost value.

The first of the great Punjab works was the Bari Doab Canal,[2] taking off from the Ravi at Madhopur and irrigating the land of the Sikhs around Amritsar and Lahore between the Ravi, the Beas and its confluent the Sutlej. The credit for this undertaking belongs to Lieutenant J. H. Dyas, of the Bengal Engineers,[3] who did for the Punjab almost as much as Cautley for the United Provinces or Cotton for Madras. These three may be termed the leading irrigation engineers of their time. Dyas was an expert who combined good mathematical ability with remarkable inventive genius. "Modern engineers are as familiar with his name," writes Sir Thomas Ward,[4] "as with the name of Cautley, and perhaps more so than with that of Napier." Dyas came to the Punjab from the Jumna Canals in 1850, and was placed under Lieut.-Colonel Robert Napier, B.E.,[5] to carry out the Bari Doab Project. He sent in his report at the end of the year, and in 1851 began work on the branch leading to Lahore, assisted by Lieutenant C. S. Paton and Lieutenant (afterwards Lieut.-General) James Crofton, B.E. For eight long years he laboured on the canal until, on April 11th, 1859, he had the satisfaction of seeing it opened before he went on furlough.[6] But, alas, many of the errors of the Ganges Canal had been repeated. The bed of the main channel scoured more and more, owing to the

[1] The Sarda Canal system was completed in 1929–30.

[2] Now called the Upper Bari Doab Canal to distinguish it from its modern prolongation, the Lower Bari Doab Canal.

[3] Biographies of Lieut.-Colonel J. H. Dyas, B.E., appear in *Addiscombe. Its Heroes and Men of Note*, by H. M. Vibart, pp. 527–529, and in *Biographical Notices of Officers of the Royal (Bengal) Engineers*, by Colonel Sir E. T. Thackeray, V.C., late R.E., pp. 174–184. He died at Delhi at the age of 43 years in March, 1868, and was buried near the great John Nicholson.

[4] Extract from notes, dated January 17th, 1933, sent to the author by Sir Thomas Ward, *Kt.*, C.I.E., M.V.O.

[5] Afterwards Field-Marshal Lord Napier of Magdala, G.C.B., G.C.S.I., and in 1850 the first Chief Engineer of the Punjab.

[6] Modifications of the original design began early, much of the revision being done by Crofton. The Mutiny also retarded the work, for most of the Mazbi Sikh labourers marched for Delhi in June, 1857, as three companies of "Pioneers" under Lieut. H. W. Gulliver, B.E., who was then employed on the canal. (See Vol. I, Chapter XVII.)

excessive slope, until all the masonry works were in serious danger. In 1868 the Ravi threatened to desert the headworks, so that these had to be rebuilt elsewhere, and by 1882 some of the channels were in a critical condition and the river supply gave signs of failure. But each difficulty was overcome as it arose, and Dyas' successors emerged triumphant at last after a struggle of thirty years. Among the men who conquered the Ravi was Major J. W. Ottley, R.E., who became President of Cooper's Hill College,[1] and later, as Colonel Sir John Ottley, K.C.I.E., a Director of Indian railways. Ottley was an exponent of the use of rapids instead of vertical falls to reduce the velocity of water in canals, and he introduced these in the Bari Doab system with good results, although they are not in favour at the present day. Too much blame should not be laid on Dyas for the errors in the original design. The country sloped three times as steeply as that traversed by the Ganges Canal, and Dyas overestimated the resistance of the soil in the lower reaches against erosion ; but at that time the defects in the Ganges Canal had not been fully investigated. Irrigation design was still in the experimental stage.

The next great irrigation work, undertaken in the Punjab by military engineers, was the Sirhind Canal, to water the Jumna-Sutlej *doab* between Ambala and Ferozepore. Baker had explored this region in 1840 and had recommended that it should be irrigated, and Dyas had outlined a scheme in 1856, but nothing was done for 20 years until the rulers of Patiala, Jind and Nabha States, who would benefit by the proposed canal, pressed for its inception.[2] The result was the submission of a project in 1868 by Lieut.-Colonel (afterwards Lieut.-General) H. W. Gulliver, R.(B.)E. There was some delay, but work began in 1874 under Major Robert Home, R.(B.)E.,[3] who laid out and built the canal. It was opened by Lord Ripon in 1882. The Sirhind Canal includes the Budki superpassage, the largest work of its kind in India, and is a monument to the ability of its designers and builders, who had profited by the lessons of the Ganges and Bari Doab Canals. The work was done under most difficult conditions. Stone had to be brought from a place 14 miles away, and timber from Patna or Calcutta, hundreds of miles distant. Heavy pumping was required, as the water-level was high and the ground spongy. Firewood was scarce and dear. Labour was difficult to get. The engineers had to dig and burn their own lime, make their own kilns and bricks, repair their machinery, build and work their railways, survey their alignments, and train their artisans. These were the conditions under which this splendid canal was made by military engineers.

[1] See Chapter XVIII.

[2] Faridkot, Malerkotla and Kalsia States are also served by the Sirhind Canal, which thus supplies nearly half its water to Indian States.

[3] Afterwards Colonel R. Home, C.I.E., and a brother of Colonel Frederick J. Home, C.S.I., who followed him as Chief Engineer of the Punjab.

During the latter part of the nineteenth century, irrigation extended farther and farther into the north-west, reclaiming desert after desert, and the next reclamation in which a military engineer was concerned was that of the Rechna Doab, between the Ravi and Chenab Rivers beyond Lahore. Proposals made in 1875 had come to nothing, and a project prepared in 1882 resulted only in the opening of a small inundation canal five years later. This work was a complete failure, so the Government decided in 1887 to convert it into a perennial canal of the first magnitude, to be called the Lower Chenab Canal, with a weir and headworks on the Chenab at Khanki, about eight miles below Wazirabad. They selected for this task Major S. L. Jacob, R.E.,[1] the greatest enthusiast of his time in matters
13 of irrigation, whose name, like that of Ottley, is still a household word in the parts of the Punjab in which he laboured. He began the work in 1892 and completed it about 1900. "The Lower Chenab Canal," wrote D. G. Harris in 1921,[2] "can claim with considerable justification to be the most extensive and successful irrigation system in India and probably in the world. It is to the initiative of Major Jacob that the Lower Chenab, as it exists at present, is mainly due, for no sooner had he assumed charge of the works than he perceived the desirability of a further extension of the sanctioned scheme, and commenced to press upon the notice of Government the advisability of the preparation of a complete survey of the watershed with a view to the formulation of yet a third project to embrace the whole area which could be commanded. His views were accepted and the necessary surveys were put in hand. The difficulties attendant on these surveys, carried out as they were in uninhabited desert, were enormous."

Through a dead wilderness, where snakes and lizards alone moved in the thorny scrub, Jacob ran the Lower Chenab Canal, which discharges 10,700 *cusecs*, is 427 miles in length including all branches, and has 2,243 miles of distributaries. Colonization started and kept pace with the works. Railways, roads, towns and manufactories followed. The Lower Chenab Canal, the last great irrigation work of a military engineer in the Punjab, is now by far the most remunerative of the larger canals of India, yielding an annual return of more than 45% on its capital account. Other huge systems have followed it—the Jhelum, which was opened in 1901, the "Triple Canals" system, which since 1917 has transferred surplus water from the Jhelum River to the thirsty deserts of the Lower Bari Doab, and the modern Sutlej Valley Project—and remarkable works have been completed elsewhere, such as the Upper Swat Canal, which burrows

[1] Colonel Sidney Jacob, C.I.E., late R.E., retired in July, 1900, and died in July, 1911. He should not be confounded with Colonel Sir Swinton Jacob, K.C.I.E., late of the Bombay Artillery, an eminent architect in India.

[2] Extracts from the *Triennial Review of Irrigation in India*, 1918–1921, compiled for Government by Mr. D. G. Harris, I.S.E., pp. 84–85.

through the Malakand Range. But military engineers have had no leading part in any of these wonderful projects and achievements, except that it was chiefly due to the representations of Colonel S. L. Jacob, C.I.E., late R.E., that the Irrigation Commission of 1901–02 recommended that the Triple Canals Project should be investigated. Their crowning exploit in the irrigation of northern India was the Lower Chenab system. Their burden has since been shifted to other, and no less capable, shoulders.[1]

We turn now to the remaining parts of what may be called Northern India—Sind in the west, and Bengal, Bihar and Orissa in the east. No two areas can offer a greater contrast than these. Sind is almost rainless, wholly dependent on artificial irrigation from its mighty river the Indus, and populated only where that irrigation has been provided. Bengal and most of Bihar and Orissa, on the other hand, are densely populated, and have a normal rainfall which in some districts is so copious that irrigation may even be harmful.

Long before the British annexation of Sind the inhabitants had tapped the waters of the Indus by scores of small inundation canals which silted up every year and required frequent re-excavation. The system was unsatisfactory and costly. It supplied water only to tracts near the river, and when that water was most needed it was not available. So Sir Charles Napier, having conquered Sind, asked Lord Ellenborough, the Governor-General, to send him the best available engineer to develop its irrigation, and the choice fell on Captain W. E. Baker, of the Bengal Engineers. In September, 1843, Baker was appointed "Superintendent of Canals and Forests in Scinde," and laboured so strenuously for more than a year on the banks of the Indus that he may be said to be the founder of the present magnificent water-supply of that desolate land. The irrigation of Sind has recently reached its climax in the stupendous Sukkur Barrage,[2] nearly a mile in length, which spans the Indus and supplied seven perennial canals. Civil engineers have accomplished this wonder, but military engineers paved the way for it. Baker reported and advised, but irrigation really began in Sind soon after Lieutenant J. G. Fife, of the Bombay Engineers, was posted as Executive Engineer at Shikarpur[3] in 1849. Fife gathered experience and developed the inundation canals of Sind for seventeen years, his work being interrupted only by periods of special duty on the Ganges Canal and the Godavari River. Rising to be Chief Engineer of Sind, he left the province in 1867 to become Chief Engineer to the Bombay Government under Sir Bartle Frere, which post he held until his

[1] Lieut. (now Colonel) G. E. Sopwith, R.E., was one of the last military engineers to serve in the Punjab Irrigation Department.

[2] The Sukkur Barrage system has 6,116 miles of canals, branches and distributaries, and has cost more than ten millions sterling.

[3] Near the Indus about 30 miles N.W. of Sukkur.

retirement in 1876. His first work in Sind[1] was on the "Desert Canal," taking off from the right bank of the Indus about 70 miles above Sukkur, though it was not till after he had left the province that the Desert Canal was so greatly enlarged and improved. He turned his attention also to the Eastern Nara works near Rohri,[2] carrying out the suggestions made by Baker in 1844 that the Nara Valley, east of the Indus, should be supplied with water. In addition he began to improve the Begari Canal between the Desert Canal and Sukkur, and the Fuleli Canal on the left bank near Hyderabad, and later the Sukkur Canal near the town of that name. These were his four outstanding achievements in Sind. All these canals were originally natural flood-spills of the Indus and they were adapted for irrigation by Fife and his assistants.

Supported by such experts as Generals Sir Richard Strachey, F. H. Rundall and James Crofton, and Colonel J. C. Anderson, all Inspectors-General of Irrigation in India, Fife remained to the end a strong advocate for perennial high-level canals for Sind. His policy has borne fruit in the gigantic Sukkur Barrage and Canals, for which he prepared the original project.[3] Sind is now a desert in little more than name, and the men who began the transformation were Baker and Fife. The former deserted canals for railways; but the latter became as eminent a specialist in large reservoirs and dams as in flood canals, and left his mark in the Deccan.[4]

Irrigation was given to Bengal, Bihar and Orissa only in small doses and in the face of apathy and even obstruction. There was a saying among the natives that, "It is better that one or two of us in each family should die of famine than that, by using irrigation for our land, we should give the Government an excuse for raising the tax on ourselves and our children for generations."[5] But Government thought otherwise. A famine such as that which occurred in 1866 was an offence against humanity, and at the same time a heavy drain on the treasury, so irrigation systems were provided or extended in selected areas, more for protection than with any hope of profit. The opposition encountered by the engineers who carried out these works is illustrated by the following statement made some years ago by an Irrigation Engineer.[6] "The natives of India," he says, "still believe or profess to believe, that when the British Government is about to commence a new work, especially if it be a work of some magnitude, the heads of human victims are buried below the

[1] Beginning in 1852.

[2] On the left bank opposite Sukkur.

[3] The "Sukkur Barrage and Canals" is the greatest irrigation undertaking which the world has yet seen. Begun in July, 1923, it was opened by the Viceroy, Lord Willingdon, on January 13th, 1932. It irrigates about $7\frac{1}{2}$ million acres. The Barrage has 66 spans of 60 feet each, and its overall length is 4,725 feet.

[4] See Chapter II.

[5] *Ways and Works in India*, by G. W. MacGeorge, p. 170.

[6] Article entitled "The Great Irrigation Works of India," by an Indian engineer, appearing in *Engineering Wonders of the World*, Vol. III, p. 239.

foundations, the heads having been collected beforehand by emissaries of the Government or the engineers. On one occasion there was a scare of this kind in Dinapore, near Patna. The natives gravely asserted that an order had gone forth for human heads, and that soldiers were killing men to obtain the necessary material. They would not dare to stir out at night unless two or three went together. Such scares as this have occurred more than once, and may serve as examples of some of the minor difficulties with which engineers have to contend." Modern India is more enlightened, but we are looking at the India of the past.

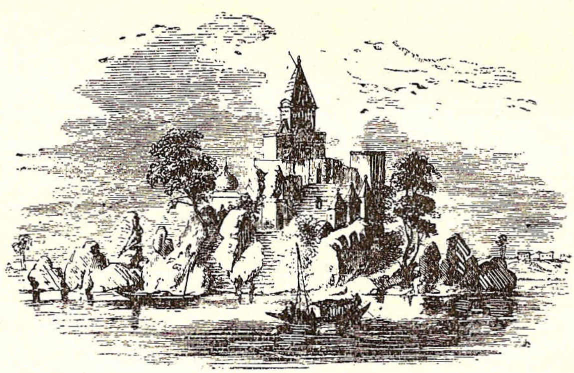
It is beyond the scope of this narrative to describe the early irrigation systems of Bengal, Bihar and Orissa in any detail. They were small in comparison with those of other parts, they involved correspondence and argument out of proportion to their size, and they were often financial failures. The largest system which military engineers helped to build was that of the Son Canals to irrigate the country lying south of the Ganges not far from Patna. The first suggestion for this project was made in 1853 by Lieutenant (afterwards Major-General) C. H. Dickens, of the Bengal Artillery, but nothing came of it until a company known as the East India Irrigation and Canal Company (of which more anon) agreed to undertake the work in 1864. This company failed, so Government took over the work in 1869 and completed it after many vicissitudes and delays. The Midnapore Canal, to the west of Calcutta, was another failure of this company, and was taken over by Government and completed in later years. Other small irrigation systems followed in Bengal and Bihar, and a number of purely navigation canals were made or improved, such as the Hijili Tidal and Orissa Coast Canals, linking Calcutta with Orissa, the Calcutta and eastern system leading towards Eastern Bengal, and some canals running northwards. None of these calls for special mention. In Orissa, however, there was a bigger undertaking. This was the Mahanadi Delta system, which was first suggested about the year 1858 by Colonel Arthur Cotton, the great irrigation expert of Southern India. A project was prepared by Lieut.-Colonel F. H. Rundall, M.E., and the work was begun by the East India Irrigation and Canal Company in 1863. Within three years the whole capital of the company had been spent, and Government was obliged to take over the works after paying the company nearly one million sterling.[1] The Mahanadi Delta system has been expensive, but it has afforded valuable protection against famine.

The names of a large number of military engineers appear in the

[1] The financial failure was due mainly to the fact that the project was framed on the incorrect assumption that there would be the same demand for water in the Mahanadi Delta as was experienced farther south; but actually the annual Mahanadi Delta rainfall is 60 inches, while that of the southern deltas is 36 to 40 inches, so less water is needed on the Mahanadi. This is an example of the early errors in irrigation design.

annals of Bengal irrigation, but more as administrators and advisers than as designers and builders.[1] Among these officers are Colonels E. L. Ommaney, R. Strachey, R. Baird Smith, A. G. Goodwyn, J. P. Beadle, F. H. Rundall, J. C. Anderson, H. W. Gulliver, J. E. T. Nicolls, F. T. Haig, H. A. Brownlow and J. M. McNeile, most of whom rose to be Generals ; but by 1895 military engineers had almost vanished from the Irrigation Department in Bengal. There were better opportunities elsewhere, and more attractive employment in the Railway or Survey of India Departments. The Military Works Department and the Sappers and Miners also required more officers. So the canals of Bengal saw little more of the Royal Engineer.

[1] Many Bengal Engineers and Royal Engineers are mentioned in *The Canals and Flood Banks of Bengal* (1908), by W. A. Inglis, C.S.I.



THE FAKIR'S ROCK ON THE GANGES.

CHAPTER II.

IRRIGATION IN SOUTHERN AND CENTRAL INDIA.

GENERAL SIR ARTHUR COTTON once remarked that there were four classes of engineers in India—those who aimed at nothing and succeeded in effecting it: those who aimed at something that was in itself a mistake, and succeeded in doing mischief: those who aimed at something right, but failed through mistakes in its execution: and finally, those who aimed at something right and succeeded.[1] The story of irrigation in Southern India can produce examples of each type, though luckily of few in the first category. Every engineer, even the great Cotton himself, occupied at times a place in one of the other categories; but the net result of their labours, and those of their successors, has now placed the areas in which they worked beyond the reach of famine. Their errors were many, for they were experimenting under novel conditions, yet their successes more than counterbalanced their failures.

The vast size of some of the irrigation works of Northern India has been described already. It is recorded that when General F. H. Rundall once propounded a scheme to store and utilize the tidal power of the Thames, a critic remarked that, "The gallant general does not appear to realize that ten million gallons of water pass under London Bridge every hour." To this Rundall answered, "We do not measure water by gallons in India, but by square miles."[2] He was thinking probably of the huge storage reservoirs of the Deccan. It may be well to explain here that there are many different types of irrigation to be found between the Himalayas and the extreme south of India. The north is watered by snow-fed rivers from the giant mountains, a regular and perennial supply from Nature's unlimited storage. The main crops are grown in the cold season when the rivers are low, and the art of the engineer is applied to irrigating the thirsty *doabs* between the rivers until the break of the south-west monsoon in June renders canal supply unnecessary. In the south-east, on the other hand, the coastal districts are dependent on the north-east monsoon which blows from the Bay of Bengal from October till the end of the year and brings a precarious supply of rain; this coast therefore relies almost entirely on artificial irrigation

[1] Letter from General Sir A. Cotton, K.C.S.I., to Sir Lewis Pelly, quoted in *General Sir Arthur Cotton, R.E., K.C.S.I.*, by Lady Hope, p. 442.

[2] "Memoir of General F. H. Rundall, C.S.I., R.E.," appearing in *The R.E. Journal*, Vol. VIII, July–Dec., 1908, p. 383.

obtained chiefly from the deltas of large rivers which are not snow-fed and are accordingly capricious in their supply. Again, in parts of Central India and the Deccan the rainfall is scanty and there are no really large rivers, so the engineer steps in and provides storage in the shape of huge lakes formed by high dams, and from these artificial reservoirs he leads small canals to selected areas. Unlike the canals of the north, these channels carry practically no silt, so their design is governed by other factors. Thus not only does the nature of the country vary in the north, centre and south of India, but the amount and incidence of the rainfall, the nature and size of the rivers, the climate, the crops and the materials available for engineering works are different. And so, in the olden days, before the irrigation of the central tableland was taken seriously in hand, two schools of irrigation engineers developed, the one headed by Cautley in the north, the other by Cotton in the south, each school learning much from the ancient canals or reservoirs which it found, and each with a very proper pride in its achievements. Separated by the arid wastes of Central India, each school worked on its own lines in its own peculiar environment.

Long before the British came to southern India, Mysore and the Carnatic were covered with thousands of reservoirs, large and small, each with its little canals. Some of these "tanks" were mere ponds. Others, such as the Chembrambakam near Madras, had a water-spread of many square miles. The British had little time or opportunity for irrigation during the building of Fort St. George, yet they sometimes thought of it. For instance, in the days of Governor Higginson at the end of the seventeenth century, the drainage channel along the west side of Black Town was embanked, regulated and used for the irrigation of the Company's ricefields, the Chief Engineer at the time being Colonel George Maule, M.E.[1] In 1779 the British engineers were looking farther afield and represented the necessity of storing the waters of the Godavari and Kistna Rivers, whose deltas lie some 200 miles north of Madras. Seven years later, Lieutenant W. C. Lennon, M.E., went so far as to make a survey of part of the Godavari at his own expense, and his reports induced the Directors to admit in 1792 that both the Godavari and the Kistna should be surveyed for irrigation and navigation. But there the matter seems to have ended. At the moment, trade and war were of more importance than agriculture.

The first serious interest shown by the British in irrigation engineering and the control of rivers seems to have followed the last Mysore War, when Captain (afterwards General Sir James) Caldwell, M.E., was sent to the newly-acquired district of Tanjore in 1804 to examine the Cauvery River.[2] Caldwell's report was discouraging.

[1] *Vestiges of Old Madras*, by Colonel H. D. Love, Vol. I, p. 585.
[2] About 180 miles south of Madras.

He predicted that the river would soon cease to be of any use for irrigation unless it was restored to its original condition, and that Tanjore was faced with ruin. About 18 miles above the head of its delta, the Cauvery is divided by the narrow island of Srirangam into two channels, the Cauvery proper at a high level and the Coleroon at a lower level, and Caldwell found that the Coleroon, having a more direct course and a greater fall, was getting most of the water, while the Cauvery, on which irrigation mainly depended, was shrinking almost to a trickle. Efforts were then made to check the rapacity of the Coleroon by throwing dams across it, but the result was a dangerous silting up of its bed, which was not remedied until 1829, when Major (afterwards Lieut.-General) D. Sim, M.E., introduced the use of undersluices from the adjacent Cauvery. For 30 years after Caldwell's visit the British engineers carried on an ineffectual struggle to check the excessive flow into the Coleroon, to improve the Cauvery supply, and to keep the canal-heads free from silt. "In 1827," remarked Colonel Cotton in a lecture at Chatham,[1] "I was sent to inspect the work as the people were said to be nearly in a state of rebellion from its neglect. I found the works in utter disrepair: the Coleroon Canal had six feet of silt in its bed." Cotton managed, with great difficulty, to get a small grant from Government; but little was done for several years, although, to use the words of the Nawab of Arcot, the water resources of Southern India were the "national bank of the country." The bank gave every sign of closing its doors. It was left to Arthur Cotton to keep them open and thus to begin his rise to fame.

Cotton had both originality and courage. Revisiting Tanjore in 1834, he proposed to control the obstreperous Coleroon by building a permanent weir across it at the head of the Srirangam Island. The scheme was approved, and a masonry work containing twenty-two small sluices was completed in 1836 and became known as the "Upper Anicut." The indigenous works had only made use of the river water during the rains, but the new anicut preserved the flood waters for the dry season, and so guarded the valuable rice crops from possible destruction. The Upper Anicut established Cotton's reputation as an irrigation engineer, yet experience showed that he did not fully realize what its effect would be. "The sluices proved utterly inadequate," writes D. G. Harris,[2] "and the bed of the Coleroon upstream rose gradually till it was level with the top of the work. The excess volumes passed into the Cauvery led to great erosion of the banks and deepening of the bed of that branch, and threatened to make the Cauvery instead of the Coleroon the main flood-carrier of the river, with disastrous results to Tanjore. Consequently, in 1843–1845, it became necessary largely to increase

[1] *General Sir Arthur Cotton, R.E., K.C.S.I.*, by Lady Hope, p. 57.
[2] *Triennial Review of Irrigation in India*, 1918-1921, compiled for Government by Mr. D. G. Harris, C.S.I., C.I.E., p. 28.

the sluiceways in the Upper Anicut, to lower its crest in a considerable portion of its length, and to construct a masonry bar, known as the Cauvery dam, across the head of the Cauvery branch." Other alterations were made in later years until Cotton's original design was changed almost out of recognition; but his mistakes and their subsequent remedies do not detract from the daring and resource which he displayed. His work on the Cauvery, in which he was assisted by his brother, Captain Hugh Cotton, M.E.[1] paved the way to greater projects on the Godavari and Kistna; its faults were not immediately apparent, and it gained him the confidence of the Government.

The success of the Cauvery scheme, and the benefits which it conferred on Tanjore, encouraged the Madras Government to extend irrigation to the Godavari Delta, which had suffered much from famine, so Arthur Cotton was sent there in 1844 to prepare a project. He recommended the construction of an anicut, channels, embankments and roads which he estimated would cost £165,000, at the same time comparing the results of forty years of gross neglect in the Godavari Delta, as he put it, with forty years of attention in Tanjore. He had his difficulties. "I asked the Board of Revenue for six officers, six or eight sappers, and others," he writes,[2] "telling them that I was done up and could do nothing myself but look on. In answer to this I got one young hand to teach and two apprentice surveyors! With scarcely strength to ride ten miles, I started on this expedition to turn the Godavari out of its bed and make it do something for its livelihood, a river only seven times the breadth of the Mississippi at a spot where I am now pitched. . . . The more I worked the stronger I became, which was well, for I had to take on, or help in, every line of level that was made, not having got one single level from my surveyors that wasn't altogether false. The site I have fixed upon for the anicut is at the head of the delta. It commands 2,000 square miles of the richest alluvial land. The river here is 6,000 yards wide including islands. The anicut would be 5,000 yards in length."

(2) The Godavari project was sanctioned by the Court of Directors in December, 1846, and Cotton began operations in the following year. He proposed to make a permanent diversion work, or series of works, across the river as he had done on the Cauvery, and he refused to copy the system adopted on the two Jumna Canals and the Ganges Canal, in which temporary obstructions or *bunds* were built annually across the rivers to divert water into the canals. The conditions in the south differed from those in the north. Cotton had his own

[1] Arthur Cotton was one of *eleven* brothers, six of whom lived to a great age. General Sir Sydney Cotton, Admiral Francis Cotton, General Frederick Cotton, and General Sir Arthur Cotton had distinguished careers in Government service.

[2] Extracts from a letter from Major A. T. Cotton, M.E., to his brother, Lieut. F. C. Cotton, M.E., quoted in *General Sir Arthur T. Cotton, R.E., K.C.S.I.*, by Lady Hope, pp. 99–100.

GENERAL SIR ARTHUR T. COTTON, K.C.S.I., LATE MADRAS ENGINEERS.

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ideas and would not be bound by convention. At Dowlaishwaram, 25 miles below the point at which the Godavari emerges into the coastal plain, he built four weirs across branches of the river, the largest being 4,940 feet in length. Altogether the Dowlaishwaram headworks comprised 2¼ miles of weir, 1½ miles of embankment, three canal-heads leading respectively to the Eastern, Central and Western Delta systems, and three sets of undersluices. The available labour was mostly unskilled, and the apparatus primitive; but the site was exceptionally good, and there was an abundance of loose stone, hydraulic lime and excellent teak in the neighbourhood. Cotton based his designs for the weirs on that of the old native anicut on the Cauvery, using the rubble stone which was available locally. His success was immediate and striking, although he made many mistakes. He built his weirs too low in the first instance, and had to raise them afterwards. They caused heavy erosion of the river bed. He overestimated the area which his canals could irrigate, and, an optimist to the core in financial matters, he greatly underestimated the cost of the whole work. By 1890, two of the canal-heads had been rebuilt by his successors, and other works altered, and in 1910 further remodelling was required. Nevertheless, his achievement was a notable one, for he showed that the most formidable rivers could be tamed; but the prolonged effort and exposure undermined his health, and in June, 1848, he went on furlough to Australia, leaving Captain (afterwards Major-General) C. A. Orr, M.E., to carry on the work. In September, 1850, however, Arthur Cotton returned to the Godavari system, completed it in 1852, and handed over charge to his brother, Captain Frederick Cotton, M.E.[1] (2)

A small but able band of assistants laboured with Cotton in the sweltering heat of the Godavari Delta. Among them were Captain C. A. Orr, M.E., who was in immediate charge of much of the construction,[2] Lieutenant F. H. Rundall, M.E., and Lieutenant (afterwards Major-General) F. T. Haig, M.E. In 1852, Haig built the fine Gunnaram Aqueduct, which carries one of the Central Delta Canals over a branch of the Godavari into Nagaram Island, and has 49 spans, each of 40-feet waterway, carrying a channel 24 feet wide. "I have the most excellent set of officers—four of them—the hardest-working fellows I ever saw," wrote Arthur Cotton to his brother.[3] "Young Haig, I think, is the most promising young engineer I have known." The opinion was justified. Felix Haig certainly proved himself one of the ablest men ever produced by the Corps of Madras (3)

[1] Captain (afterwards Major-General) F. C. Cotton, M.E., saved the southern forests of India from gradual destruction after the year 1848, and it was mainly due to his efforts that the Indian Forest Department was founded in 1862.

[2] *The Engineering Works of the Godavari Delta*, by G. T. Walch, Vol. I, p. 40.

[3] Letter to Captain F. C. Cotton, M.E., quoted in *General Sir Arthur Cotton, R.E., K.C.S.I.*, by Lady Hope, p. 119.

Engineers. He prepared designs for the navigation of the Godavari and completed a great dam and locks at the first barrier, and afterwards made his mark as Chief Engineer in the Central Provinces, and finally in Bengal.[1] Haig was one of four Madras Engineers who were transferred to high office in Bengal, the others being General F. H. Rundall, raised to the head of the Irrigation Department in India, Colonel J. H. Bell as Secretary to Government in the Public Works Department, and Colonel John T. Smith as Mint Master.[2] Colonel Smith was afterwards appointed Consulting Engineer of the Madras Irrigation Company, which figures later in this narrative, and finally became Chairman of the Madras Railway. Was there ever a more varied career? And when he was a youngster at Masulipatam he set himself to make a reflecting telescope of five feet focus. After trying 84 mixtures of metal he found one which was sufficiently hard, made his reflector, and employed a man for several months to polish it. He left the telescope at Masulipatam, and an astronomer who found it there said that it was a first-rate instrument worth £200.

But to return to the watery subject of irrigation. For many years prior to the damming of the Godavari, proposals had been made for supplying irrigation to the delta of its neighbour the Kistna. About the year 1792, Major Alexander Beatson, of the Madras Infantry, the "Surveyor-General" who planned the successful attack of General Harris' army on Seringapatam in 1799,[3] advised the Government to build an anicut on the Kistna at Bezwada, 60 miles from its mouth, and the Government referred the matter to its astronomer, Mr. Michael Topping, who spent nearly three years in surveying the river in company with Captain J. L. Caldwell, M.E.[4] Topping's reports and surveys, however, languished for almost half a century in the pigeonholes of Leadenhall Street until the great famine of 1832–33 stirred the complacent Directors into action. Human beings were then dying by hundreds of thousands while the giant Kistna rolled its mighty volume unhindered to the sea. Some irrigation works were begun, but not till 1839 were the recommendations of Beatson and Topping brought to notice in two reports from Captain Edward Buckle, M.E. Yet the Madras Board of Revenue remained sceptical. The members remarked in 1840 that "very large and costly works like an Anicut at Baizwarah are clearly inexpedient and impracticable," and had it not been for Arthur Cotton it is probable that the Kistna scheme would have been shelved for many a year. But Cotton's enthusiastic report about the Godavari in 1844 drew attention once more to the Kistna, and Lieut-

[1] A Memoir of Major-General F. T. Haig appears in *The R.E. Journal*, Sept. 2nd, 1901.
[2] See Chapter XVI.
[3] See Vol. I, Chapter X.
[4] *The Engineering Works of the Kistna Delta*, by G. T. Walch, Vol. I, p. 9.

enant H. A. Lake, M.E.,[1] was sent there to prepare a scheme for an anicut. This he submitted in July, 1847, and the matter was then referred to a committee of experts, including Captains C. A. Orr, J. H. Bell and E. Buckle, who reported so favourably that the project was sanctioned in 1851 and the work was entrusted to Orr. No better selection could have been made, as Orr had just completed the great weir across the Godavari under the guidance of Arthur Cotton. At Bezwada, the site chosen for the Kistna weir, the river flowed between rocky hills 3,900 feet apart; but although this width was much less than at Dowlaishwaram on the Godavari, it was no child's play to build, on pure sand, a masonry dam 15 feet high across a gorge in which the river rose 40 feet when in flood. By 1855, however, Charles Orr had completed the work successfully, rapidly, and without any serious mistakes, and so, by a system of canals on either bank, brought the blessings of irrigation to the Kistna Delta.

With the completion of this undertaking by his able lieutenant, Arthur Cotton may be said to have reached the pinnacle of his fame. It is most unfortunate that his devotion to irrigation, his superabundant energy, his vivid imagination, his unshakable optimism and his inaccuracy in financial estimates should afterwards have led him to propound impossible schemes which brought him into disfavour. To his mind, the salvation of India lay in the extension of irrigation and navigation canals. He deprecated the building of railways, against which he launched most bitter criticisms. So, after Orr had finished the Kistna works, Cotton cast about for new worlds to conquer. Soaring into the realms of fancy he pictured a vast system of canals radiating east and west from the Tungabhadra[2] and Kistna, with four weirs on the former and a fifth on the latter. Storage reservoirs were to be prepared holding more than 50,000,000,000 cubic feet of water to maintain a navigation supply for canals. A cut was to be made to divert part of the water of the Tungabhadra into the Penner, and five large canals were to be excavated. Canals were to be extended across India to Poona and the west coast, and up to Ahmadnagar and down to Mangalore. The cost of this project alone was placed optimistically at two millions sterling.

In 1858 Arthur Cotton came forward with still more ambitious proposals affecting almost the whole of India. He recommended the construction of a huge irrigation and navigation system, starting from Rajmahal on the Ganges, which would include the junction of Calcutta with that river by a navigable canal. This line was to be connected with the Ganges Canal at Cawnpore by a channel 550 miles

[1] Afterwards Colonel Sir H. Atwell Lake, K.C.B., who fortified Kars for the Turks when that town was besieged by the Russians in 1855. (See *The Military History of the Madras Engineers*, by H. M. Vibart, Vol. II, pp. 240–278.)

[2] One of the largest tributaries of the Kistna.

long, completing a line of 1,200 miles to Hardwar. A branch line, 200 miles in length, was to join the Ganges Canal to the Sutlej River, thus uniting the system of navigation in the Punjab with that of the Ganges. The Orissa Canals, then under consideration, would provide a navigable line along the east coast which would be extended through the Godavari and Kistna deltas and joined, through the Tungabhadra project, with Madras and the west coast. In other words he contemplated a navigable line, 4,000 miles in length, from Karachi by Cawnpore, Calcutta and Cuttack to Bhatkal, Mangalore and Madras. "There is not a single obstacle to this," he wrote, "and the results would be far beyond calculation." But whatever might have been the results of such an undertaking, it is probable that the cost would have proved to be far beyond the estimated amount of thirty millions sterling.

The Government, however, could not finance even the Tungabhadra scheme, so it was decided to entrust it to private enterprise, and the Madras Irrigation Company was formed in 1863 to build a canal fed by three reservoirs on tributaries of the Tungabhadra. But only one section of the scheme, now known as the Kurnool-Cuddapah Canal, was ever taken in hand, and before it was finished the Company was bankrupt and was only able to continue work after receiving a loan from Government. In 1882 the Government was compelled to buy out the Company, and it was then found that the Crown had paid for a fragment of the Tungabhadra scheme as much as had been estimated as the cost of the whole. The truth is that, in the Kurnool-Cuddapah district, irrigation was not really necessary. To quote the *Triennial Review of Irrigation in India*[1] :—"The extraordinary oversight which led to the unhesitating construction of these great works without regard to the character of the soil to be watered, to the people who owned it, or to the results to be obtained by its execution, is one of the most remarkable and at the same time most regrettable incidents in the history of Indian irrigation." The failure of the Madras Irrigation Company reflected to some extent not only on its Chief Engineer, Major Hugh Cotton, late of the Madras Engineers, but also on his distinguished brother, Colonel Arthur Cotton, who had conceived the scheme; and although Arthur Cotton maintained to the end that the works were properly executed,[2] their heavy cost and their subsequent failure to bring in enough revenue went far to lower him from his pedestal.

On the top of this unfortunate affair came the failure of irrigation in the Mahanadi Delta in Orissa, which has been mentioned in Chapter I. In 1858 the Government had sent Cotton to inspect that delta, and he had advised an expenditure of no less than £13,000,000 on canals to protect the people against famine. The necessary funds

[1] *Triennial Review of Irrigation in India*, 1918–1921, compiled by Mr. D. G. Harris, I.S.E., p. 51.

[2] *General Sir Arthur T. Cotton, R.E., K.C.S.I.*, by Lady Hope, p. 227.

being lacking, it was resolved once again to entrust the work to private enterprise, and the East India Irrigation and Canal Company was formed in 1860 to execute it. A project was prepared by Lieut.-Colonel F. H. Rundall, M.E., and work began in 1863 on a modification of the original scheme; but within three years the Company was in serious financial straits and the Government was obliged to take over and finish the work at a huge cost. Alfred Deakin does not attribute the failure to the engineers, except that the cost proved to be twice as much as was originally estimated and that there was some extravagance in construction;[1] but the result of the venture was nevertheless a heavy blow to Cotton's reputation.

The Mahanadi system, like those on the Godavari and Kistna, was to be traversed by some purely navigation canals to assist the traffic on the irrigation canals and rivers. It should be explained here that navigation canals had existed in India for many years, the oldest British work being the Buckingham Canal, extending along the Coromandel Coast for 262 miles. So far back as 1801 a Mr. Basil Cochrane had financed a certain Mr. Heefke in the construction of some miles of this canal, which runs through Madras, naming it the "Lord Clive Canal," though later it became known as "Cochrane's Canal," and then as the "East Coast Canal." It was taken over by Government in 1837 and gradually extended until, during the famine of 1876–77, the Duke of Buckingham, then Governor of Madras, accelerated the work and gave the canal his name. There is little doubt that the greater part of the canal was designed and excavated by military engineers. The Buckingham and other navigation canals were useful highways for merchandise before the development of railways, and figured in Arthur Cotton's imposing schemes for navigable canals throughout India. "Sir Arthur Cotton," says Colonel W. M. Ellis,[2] "was a convinced champion of navigable irrigation channels. For myself, I am positive that in the case of the Godavari and Kistna Canals the making of them navigable was both directly and indirectly a paying proposition. Had it not been for cheap transport, the cost of the construction and maintenance of the masonry works would have been at least 50% higher, while the cost to the cultivators of exporting their produce would have been doubled."

Railways have killed navigation canals in England and are killing them in India. Cotton always asserted that Indian railways could not possibly compare or compete with irrigation and navigation canals as a preservative against famine, and indeed that a multiplicity of railways was a luxury which India could not afford. But it is evident that the commercial, agricultural, administrative and military needs of modern India could never be met by strings of

[1] *Irrigated India*, by the Hon. Alfred Deakin, p. 285.
[2] Extract from notes sent to the author in January, 1933, by Colonel W. M. Ellis, C.I.E., late R.E.

barges moving slowly along navigation canals or fighting the current in irrigation canals. Railways are expensive to build and maintain, but they are indispensable in the development of a country which has few good roads. Yet Cotton would never admit this fact. His unfulfilled dreams of universal irrigation, and his opposition to railways, drew upon him several bitter attacks by Lord George Hamilton and others in the House of Commons in 1878, long after he had left India. To these he replied to the best of his ability and with considerable effect. Arthur Cotton was sometimes too ambitious, over-confident, and careless in estimates, but he was a grand engineer—the best military engineer who ever served in the Irrigation Department south of the Jumna, and perhaps anywhere in India. His services were acknowledged by the Madras Government in 1858 in the following remarkable words :—" Colonel Cotton's name will be venerated by millions yet unborn, when many, who now occupy a much larger place in the public view, will be forgotten." And so we leave him, the creator of works which saved many thousands of lives.[1]

(4)

The name of Colonel John Pennycuick, C.S.I., late of the Madras Engineers,[2] will ever be associated with one of the boldest irrigation projects in India, for it was he who planned and built the Periyar system which supplies water to Madura in the extreme south. This scheme involves nothing less than the diversion across the Indian peninsula into the Bay of Bengal of a river which would naturally flow in the opposite direction into the Arabian Sea. To perform this marvel, Pennycuick had to make a reservoir by building a huge dam in a remote gorge situated 3,000 feet above the sea in dense and malarial jungle, and to conduct the water from this artificial lake through a mountain range by a long tunnel. The Periyar River, rising in the Western Ghats in Travancore, once descended westwards through impenetrable forests where the water was useless ; while within a few miles of it, on the eastern side of the watershed, the plains of Madura were crying for a greater supply than the small River Vaigai could give. Captain J. L. Caldwell, M.E., had visited the neighbourhood in 1808 and had considered the possibility of diverting the Periyar into Madura through a cutting in the mountains; but when he found that the excavation would have to be more than 100 feet deep, he relinquished the project as " decidedly chimerical and unworthy of any further regard."[3] Nevertheless the subject was discussed from time to time, and in 1862 the project was revived by Captain J. G. Ryves, M.E., who submitted proposals in 1867 for

[1] Arthur Cotton was knighted in 1861, in which year he left India, though he returned as an engineering adviser in 1862 and 1863. He became a K.C.S.I. in 1866, was promoted to General in 1876, retired from the Army in 1877, and died on 24th July, 1899, at the age of 96 years.

[2] Colonel John Pennycuick, C.S.I., retired in 1896 and died on March 9th, 1911.

[3] *History of the Periyar Project*, by A. T. Mackenzie, p. 9.

an earthen dam 162 feet high to divert the river through a cutting into the Vaigai valley. Further discussion followed, and considerable delay was caused by the terrible famine of 1876–77, but in May, 1882, Major Pennycuick was placed on special duty to prepare a revised project and estimate.[1] These were approved by Colonel H. A. Brownlow, late B.E.,[2] and sanctioned in 1884, but owing to lack of funds the work did not begin until 1887.

The principal feature of Pennycuick's scheme on the Periyar is a concrete and masonry dam, 173 feet high and 1,241 feet long at the crest, impounding more than 15,000,000,000 cubic feet of water. From the northerly arm of the reservoir so formed the water runs for about a mile through a deep cutting, and then, by a tunnel 5,704 feet in length, into another cutting on the eastern side which leads it into a natural ravine and so to the Vaigai River. Some 86 miles from the exit of the tunnel, the Periyar Canal takes off from the semi-artificial Vaigai River and discharges 2,000 *cusecs* into branches which supply the fields of Madura. The Periyar project is one of the most extraordinary feats of engineering ever performed by man. The chief difficulty in building the great dam was to divert the river while the lower portions of the work were in progress. Floods in the narrow gorge often swept away the temporary embankments and coffer-dams. The labour involved was herculean, and the mortality from malaria was high. Indeed, it is said that, had it not been for the medicinal effects of the native spirit called *arrack*, the dam might never have been finished. The ordinary labourers were lethargic through sickness, and the masons so unskilled that any ambitious coolie who could borrow or steal a pair of old boots and a trowel was ready to present himself unblushingly for the job. Military labour was tried in 1889 and 1890, when detachments of the 1st and 4th Madras Pioneers were lent for service on the Periyar, and Portuguese carpenters from Cochin were employed in making the coffer-dams and other structures. In 1896, after an expenditure of 104 lakhs of rupees, water from the Travancore jungles was pouring through the tunnel to Madura. The chief credit for that unique exploit belongs to a military engineer.

In the Madras Presidency the number of military engineers in the Irrigation Department diminished gradually with the departure of Arthur Cotton. Only one R.E. officer joined it after the year 1876,[3] all the other recruits being civil engineers. For many years after the completion of the Periyar project no irrigation scheme of any great importance was approved, the reason being that by 1886 the rivers had been tapped of as much water as they could give by direct flow, and any further supply had to be drawn from storage reservoirs.

[1] Pennycuick had been in touch with the scheme for many years, having examined the proposals in 1870.

[2] Colonel (afterwards Lieut.-General) H. A. Brownlow was then Inspector-General of Irrigation in Madras.

[3] Lieutenant (now Colonel) W. M. Ellis, R.E., in 1888.

It is impossible, in most of the southern areas, to provide reservoirs of medium size, as commercial propositions, at the rates usually paid for water: only the very largest reservoirs can be expected to be remunerative. Thus, although a number of reservoir projects were considered during the first few years of the present century—among them two for the Kistna, one for the Tungabhadra and two for the Cauvery—all except one for the Cauvery, known as the "Mettur Project," which was drawn up by Colonel W. M. Ellis, late R.E., in 1909–10, were postponed or abandoned. The Mettur scheme was not sanctioned until 1924, and a revised estimate was approved in 1929, when the work was begun under Mr. C. T. Mullings, I.S.E. It was completed in August, 1934, at a cost of about £5,000,000, and is the largest undertaking in Madras since the Kistna project of some 80 years ago. A gigantic dam of concrete and rubble stone, 176 feet high and 5,300 feet long, impounds the water of the Cauvery to form a reservoir 34 miles in length, and supplies canals which add to the irrigation of the delta.[1] The credit for the inception of this great undertaking rests with Colonel Ellis, who also designed and built many works on the Kistna and Godavari and supervised the Divi Island Pumping Project in the Kistna Delta in 1908–10.[2] Ellis introduced reinforced concrete construction into the Madras P.W.D. in 1902,[3] and was the last R.E. officer to serve in the Madras Irrigation Department.[4] He and Colonel A. W. Smart, late R.E., who remodelled the regulators on the Cauvery anicuts and retired as Chief Engineer in 1905, will be remembered as the last military representatives in Southern India in a branch of engineering which was founded by Arthur Cotton and other soldiers.

The life of an irrigation engineer is often very lonely, and few Royal Engineers who have spent their youth in the large military stations of England and India can endure it. When irrigation engineers collect for some large project they can enjoy each other's society in the intervals of hard and strenuous work, even though camped, as they often are, in some unhealthy and remote spot. These are the lucky ones who are on "construction" as opposed to "maintenance" work. The engineer on maintenance duty tours his miles of canal bank, and having finished the routine work of the day and perhaps shot a bird or two, seeks his solitary meal and couch in some little canal bungalow, looking forward eagerly to his next brief spell in a civil station when he may see a white face again. A few irrigation officers may be found in the sacred precincts of the Government Secretariat, but these are the experienced seniors or the

[1] Details of the Cauvery Metur Project are given in the issues of *Civil Engineering* dated April and May, 1932.

[2] To irrigate 35,000 acres of rice by pumping from the Kistna River.

[3] It may be remarked, however, that reinforced concrete construction was used in 1901 by Captain (afterwards Brig.-General) E. R. B. Stokes-Roberts, R.E., in building the Cordite Factory near Coonoor in the Nilgiris.

[4] Colonel W. M. Ellis, C.I.E., retired as Chief Engineer in 1919.

selected juniors. The long vista of an Indian canal is tinged with a melancholy which sets its mark on many a man. Yet the life is not always lacking in humour or in humorists. There is the tale of the young engineer who wanted to visit headquarters to attend a race-meeting and applied for leave to come in on the ground that he could not get his hair cut in camp. The request being refused, he wrote later to say that his hair was now so long that it fell over his eyes and prevented him from corresponding with Government. The mighty one at headquarters, who had never seen the applicant, then gave in and sanctioned the leave; but shortly afterwards, happening to meet the youngster at dinner, he was astounded to observe that the man was completely bald. It is said also that a young canal engineer, having been hauled over the coals for extravagance in stationery and postage, hit upon the brilliant idea of conducting his official correspondence on the thinnest and lightest paper he could get—a well-known brand sold by chemists. Again there is a tale that a kind-hearted engineer, seeing a fat Indian riding along the canal bank, followed by a heavily laden woman on foot, hauled the man off the pony and placed the woman on it. After accompanying the pair for some miles to see fair play, he noticed that the woman was crying. "Well, what's the matter *now?*" said he. "You are riding and your husband is walking." "Huzoor," she replied, "I do not know this man, and you are taking me away from my home." Major-General H. W. Duperier, late R.E., who served for a time in the Irrigation Department, records the case of an animal that was most useful in accelerating official business. It seems that he once caught a baby otter and reared it as a pet till it was full grown. Whenever a bare-footed native petitioner came to the canal bungalow to state his case, the otter would listen quietly for a minute or two and then steal round and gently nip the man's heels. Long-winded complaints were unknown while Duperier toured, and the interests of Government were safeguarded.

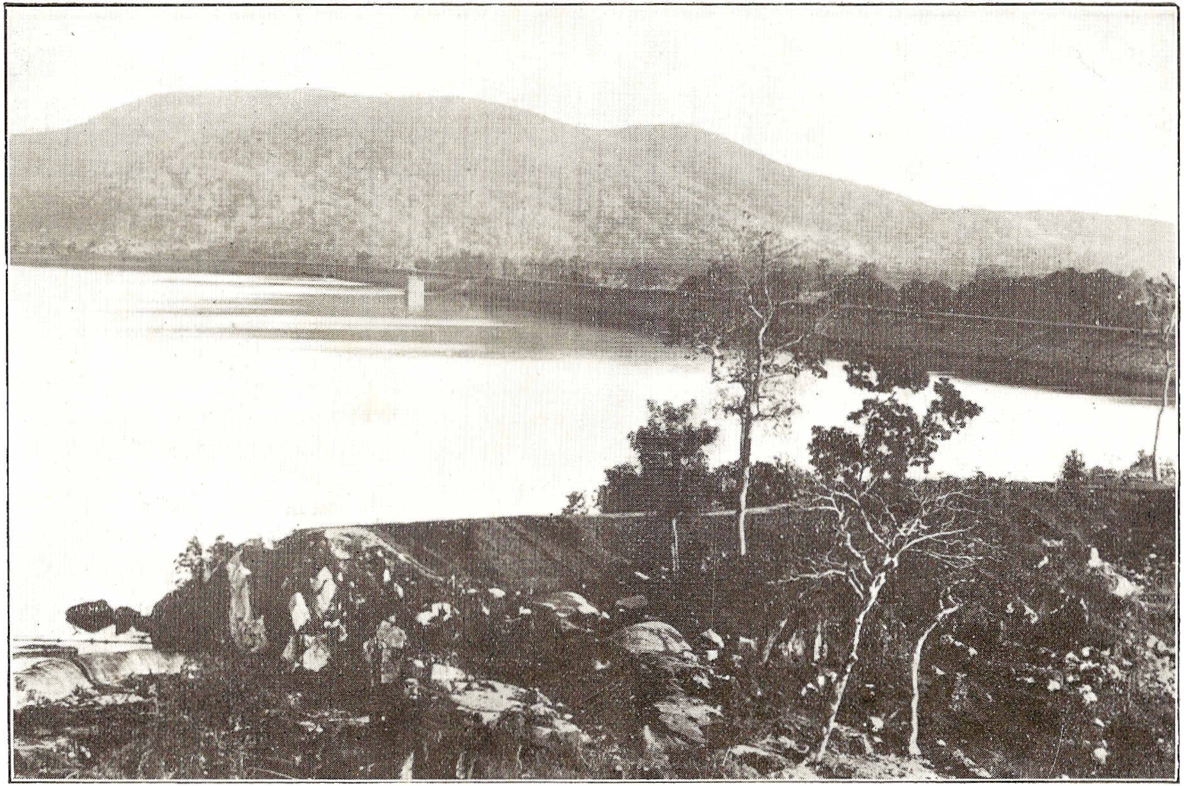
We turn now to the Bombay Presidency, which consists mainly of a strip of mountainous coast country interspersed with high plains and intersected by small rivers whose flats are very fertile. Large tracts are covered with a friable black soil which needs little or no watering; but elsewhere, if irrigation is contemplated, the water must be supplied from reservoirs, which are very expensive to build and maintain. Bombay cannot have long weirs, diverting water from mighty rivers into wide canals, but has to rely instead on high masonry or concrete dams forming great artificial lakes which store water for small canals. In no part of India is irrigation more necessary as a protection against famine; yet it could not be undertaken until Government could find the money for reservoir construction, and hence the north and south of India had a long start over the centre in the race for water. Nevertheless, the problems of Bombay,

and particularly of the area called the "Deccan," were tackled in due course so that this Presidency has now some of the finest reservoir systems in the world. In the earlier days of the work, the military engineers of India took a leading part; in the later stages they were replaced by their brethren, the civil engineers.

There is one name which is connected inseparably with irrigation in Western India—that of Colonel J. G. Fife, late of the Bombay Engineers, who retired as a Lieut.-General in 1878. Not till he came from Sind to Bombay as Chief Engineer in 1867 did irrigation really prosper in the Western Presidency. He was stoutly supported in all his proposals by Major-General Richard Strachey, the Inspector-General of Irrigation in India, a financial expert who did more to induce the Home and Indian Governments to develop this branch of engineering throughout the country than any other man of his time.[1] It is true that irrigation in Bombay was begun in a small way in 1851 on the Panjhra River in Khandesh, and afterwards in other places; but it was Fife who in 1865, while on deputation from Sind, made the first proposals for the Mutha Canals scheme by which India entered on a new field of endeavour—the building of great masonry dams. He put forward a project in 1868 to span the Mutha River at Khadakwasla above Poona with a masonry dam 99 feet high and 5,136 feet long, and to run two canals from the reservoir so formed to supply Kirkee and Poona with water and to irrigate the country beyond. Construction began in 1869, and the scheme was finished ten years later. The building of a very large earthen dam had been undertaken by Fife in 1866 some five miles north of Sholapur to form the Ekruk Reservoir, from which three canals were to take off, but afterwards he discarded earth in favour of stone for his dams. The reservoir for the Mutha Canals, which is over five square miles in area, is still known as Lake Fife.

Another scheme which Fife originated was that of the original Bhatgar Reservoir, known as Lake Whiting, situated on the Yelwandi River, a tributary of the Nira, about 40 miles south-east of Poona, with a pick-up weir on the Nira itself some 20 miles lower down. This reservoir had a masonry dam 127 feet high and 4,067 feet long, and impounded 5,300,000,000 cubic feet of water. Its construction was sanctioned in 1881, five years after Fife had left India, and it was completed in 1885, although the Nira Canals scheme as a whole was not in full operation until nine years later. This and other projects were framed as relief works during the famine of 1876–77. Altogether fourteen large schemes in the affected area were designed under Fife's orders, and all except one were completed in after years. Since his departure the irrigation of Bombay has progressed rapidly, though with occasional interruptions, under the guidance of eminent civil engineers. The lofty Bhandardara Dam, 270 feet in height, for

[1] *Indian Polity*, by Lieut.-Colonel G. Chesney, Royal (late Bengal) Engineers, p. 424, footnote.



THE MANIARI RESERVOIR, CENTRAL PROVINCES.

the Pravara Canals south of Nasik, and the new Bhatgar Dam, 60 feet higher than Fife's dam and a short distance below it,[1] are masterpieces of twentieth-century work in which, however, military engineers have taken no part. But the soldiers led the way in Bombay as elsewhere. "It has been necessary," writes Deakin,[2] "to build up the Empire of India, as Jerusalem was rebuilt in the time of Ezra, sword in one hand and trowel in the other. To the men of the sword rightly belongs the chief share of the honour, even of its pacific achievements." Colonel Fife was one of those "men of the sword" who did much for the prosperity of Western India.

Storage works made an early appearance in dry and dusty Rajputana, where there are no rivers on which reliance can be placed for irrigation, and the men who were responsible for providing them in the Ajmer-Merwara District were Colonels Dixon and Hall,[3] neither of whom was an engineer by profession. Dixon began the task in 1835, and by 1864 had made more than 2,000 small tanks and over 9,000 wells. He used masonry, or masonry backed with earth, for his dams, some of which were 30 feet or more in height. Another engineer by adoption did fine irrigation work in Jaipur State from 1867 onwards. This was Colonel Samuel Swinton Jacob,[4] late of the Bombay Artillery, who laboured for more than 33 years to provide the State with tanks, small canals and wells. "I am told," says Lady Hope,[5] "that when Colonel Jacob goes about the country, the people of the unirrigated districts surround him as if he were the god of water and beseech him to give them canals."

The last British territories in India to receive the boon of irrigation were the Central Provinces. Irrigation on a small scale had been practised by the people of those parts for centuries, but extensive works were not considered necessary until a cycle of dry years beginning in 1897 culminated in a disastrous famine in 1899. Money was then literally poured out by Government, and works were started everywhere to relieve distress. At one time nearly 2,000,000 people were receiving famine relief. There had been partial failures of rain in 1862 and later years, but the general opinion seems to have been that the Central Provinces were fairly immune from famine, and in 1880 a Famine Commission reported that, "In the greater part of the country the rainfall has never been known to fail and no part of India is more free from apprehension of famine." Yet famine came, and with it an era of concentrated effort. Projects were prepared for no less than 187 tanks, varying greatly in size but including many of more than five square miles in area and one (the Tandula, south of

[1] It replaced Fife's dam, which was dismantled.
[2] *Irrigated India*, by the Hon. Alfred Deakin, p. 232.
[3] *Imperial Gazetteer of India, The Indian Empire*, Vol. III, p. 343.
[4] Afterwards Colonel Sir Samuel Swinton Jacob, K.C.I.E., the noted architect.
[5] *General Sir Arthur T. Cotton, R.E., K.C.S.I.*, by Lady Hope, p. 371.

Drug) with a waterspread of 16 square miles. There are no snow-fed rivers in the country around Nagpur, Jubbulpore and Drug, and the largest rivers, such as the Mahanadi and the Wainganga (a tributary of the Godavari), carry little water except during the monsoon between June and October. Reliance had accordingly to be placed almost entirely on reservoirs, the only attempt at irrigation by direct flow alone being made on the Wainganga.

Conditions in the Central Provinces differ from those in all other parts of India, and it was soon apparent that the engineers would have to rely very largely on their own investigations. Foremost in this work were Captains H. de L. Pollard-Lowsley[1] and A. ff. Garrett, R.E., who were posted to the Central Provinces a few years after the great famine, Pollard-Lowsley in 1904 and Garrett in 1905. Garrett was an inventive genius who, as State Engineer at Alwar, had already put into practice a new theory of arched masonry dams. Soon after he took charge of the Mahanadi Division in the Central Provinces, he revolutionized the design of reservoir spillways by his investigations into the theory of flood storage; and hardly had he finished these researches when he set to work on a series of hydraulic diagrams for the design of irrigation channels which have made it possible to ascertain almost at a glance the best section for any given conditions.[2] He supplemented these diagrams by others almost as valuable, but his irrigation career was then cut short by the Great War. Badly wounded in Gallipoli, and overworked after his return to India in 1916, his health gave way after he had served in the Third Afghan War in 1919, and he died in the following year while on his way to England.[3] No more brilliant military engineer than Arthur Garrett, or one of greater promise, has served in the Irrigation Department since the days of Cotton. By his early death the Central Provinces sustained an irreparable loss.

There are now three canal systems in these Provinces—the Wainganga, near Balaghat,[4] the Tandula close to Drug, and the Mahanadi a few miles farther east near Raipur. These are reinforced by some two dozen large reservoirs and more than 100 small tanks. The whole of this development, which has cost nearly three millions sterling, has taken place since the beginning of the present century, and the chief credit for its engineering feats may be given to Pollard-Lowsley, who succeeded Colonel S. G. Rivett-Carnac, late R.E., as Chief Engineer shortly after the Great War, and held the post for ten years until his retirement in 1932. Rivett-Carnac had been in charge of the works on the Mahanadi and Tandula Canals for some

[1] Now Colonel H. de L. Pollard-Lowsley, C.M.G., C.I.E., D.S.O. The author is indebted to him for valuable notes on irrigation in the Central Provinces.

[2] "Garrett's Tables" are known and used all over India.

[3] A Memoir of Major Arthur ffolliott Garrett, O.B.E., R.E., appears in *The R.E. Journal*, Vol. XXXII, July–Dec., 1920, pp. 76–78.

[4] 80 miles N.E. of Nagpur.

years before the war,[1] and then, becoming Chief Engineer, occupied that post during most of the war, as he was physically unfit for active service, and continued in it to the time of his retirement in 1922; but the burden of post-war development and reorganization, and the completion of schemes interrupted by the war, fell on Pollard-Lowsley. The latter returned in 1919 from field service in France, rejoined in the Central Provinces as Chief Engineer, Buildings and Roads Branch, in 1920, after a period of duty under the Government of India, and in 1922 became Chief Engineer in the Irrigation Branch.

Work on the Mahanadi, Tandula and Wainganga Canals, which began between 1909 and 1911, was seriously interrupted by the Great War, though it is now some years since it was finished. "Not only was there a great shortage of competent officers," writes Pollard-Lowsley, "but much difficulty in getting plant for the works. One result was that the Muramsilli Reservoir, which holds the reserve supply for the Mahanadi Canal, was not completed, and did not come into operation, until 1924. This very seriously affected the working of the canal, which failed to irrigate satisfactorily in 1918 and 1920, when there was a big demand for water. The Tandula Canal, however, has always done well, and the Wainganga Canal has proved very reliable. Between 1909 and 1920, in addition to the three large canals, estimates for 12 works of considerable size were sanctioned, and for eight more between 1920 and 1925; but work on three of these has been suspended indefinitely owing partly to financial stringency. A halt has now been called in the construction of new works." Nevertheless the Central Provinces are now reasonably secure against famine; and great reservoirs such as the Ramtek[2] in the Nagpur District, and the Maniari[3] in the Bilaspur District, bear witness to the protective care of Government and the ability and industry of a few of those military and civil engineers who have devoted their lives to irrigation.

Far across the Bay of Bengal lies Burma, which is popularly supposed to be a land of tropical jungle and swamp, deluged for months by rain and ravaged by malaria. And so it is in certain parts and at certain seasons. But there exists in Upper Burma a so-called "dry zone" between Minbu on the Irrawaddy and Shwebo north of Mandalay, a tract from which the Arakan Hills divert the rainfall, and it is here that the Mandalay, Shwebo, Yeu and Mon canal systems[4] are found, and also hundreds of small works, many of which were built by the Burmese before the country was annexed

[1] He joined the Irrigation Department, C.P., in 1905.

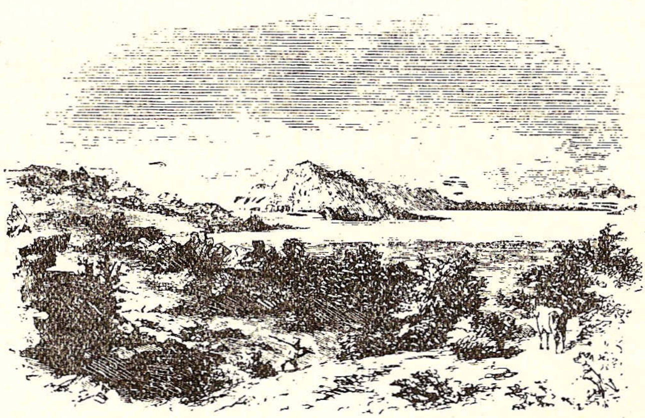
[2] The Ramtek Reservoir is formed by an earthen dam 73 feet high.

[3] The Maniari Reservoir and Canal were designed and built under the direction of Colonel Pollard-Lowsley. The dam is 95 feet high and about 2 miles long, and the full waterspread is 9·8 sq. miles. Construction began in 1924 and the work was finished in 1930 at a cost of about 62 lakhs.

[4] The Yeu system is near Shwebo; the Mon system near Minbu.

by the British in 1885. No attempt, however, will be made in these pages to describe the irrigation canals and reservoirs of Upper Burma and the navigation channels of the area between Henzada, Bassein and Rangoon in Lower Burma, because these are mostly products of the present century, or adaptations of native works, in which military engineers have not been concerned. Burma, as well as India, benefited by the recommendations of the Indian Irrigation Commission which toured both countries in 1901 and 1902 under the presidency of a military engineer—Colonel Sir Colin Scott-Moncrieff, K.C.M.G., C.S.I., late R.E.—and these recommendations gave a tremendous impetus to construction from 1905 onwards.

Irrigation bids fair to vanish from the province of the Royal Engineer: indeed it may be said to have gone already. This is inevitable. The specialized nature of modern warfare now demands a more profound study of military engineering than in the nineteenth century, and leads to the exclusion of everything which is of little value in the field. Railway engineers, mechanical and electrical experts, surveyors and even roadbuilders have their place in war. But how often would the irrigation engineer be required to ply his trade in the zone of actual fighting where every trained soldier should be? Colvin, Cautley, Cotton, Dyas, Baker, Jacob, Fife, Orr, Pennycuick and others blazed a trail which has been followed and ramified by the civilian experts of Government. The military engineer in India has turned from irrigation and agriculture to preparation for war, exchanging the ploughshare for the sword.



LAKE OF MOOTY TALLAOW, NEAR BANGALORE.

CHAPTER III.

WATER-SUPPLY, DRAINAGE, AND HYDRO-ELECTRIC SCHEMES.

FOR many years after the British set foot in India, they do not seem to have troubled themselves overmuch about drinking-water, whether with or without the hyphen. They drew it, as the natives did, from polluted rivers, tanks and wells, and they paid the penalty in cholera or dysentery, ignorant of the source of the pestilence which struck them down. But water-supply for various purposes began to engage their attention before the end of the seventeenth century. In Madras, a patent for a water-lift was granted in 1695 to a merchant named John Coventry :—[1]

" Whereas John Coventry, Inhabitant of this place, hath by his Petition signified to us that he had been at great expence and trouble in contriveing and makeing an Engine for the drawing of water, which when perfected would be a publick benefit and advantage to the place, Wee, the President and Councill, grant unto him, his heirs and assigns, the sole liberty and priviledge for makeing said Engine with three wheels for the drawing of water during the space of seven years."

Little seems to have come of this venture. Cisterns were made in the ramparts of Fort St. George, and these were filled with water brought through earthen pipes laid by Paul Benfield, a contractor, or carried to the cisterns in carts. In 1771, however, a certain Captain George Baker, late Master Attendant, proposed to undertake at his own expense to convey water by a pipe-line to the Fort in sufficient quantity to last three thousand men for three months,[2] and an agreement was made by which Baker was to supply and keep full the Fort reservoirs, which actually held sufficient for six thousand men for four months. Baker was as good as his word. He began operations at a spot called Seven Wells, some two miles from the Fort, and by July, 1773, with the assistance of a Mr. Standish Lee, had completed a metal pipe-line to fill the reservoirs. Ten years later, the works were bought from him by Government, when more than £40,000 had been spent on them. This appears to be the first piped water-supply system of any considerable size which was made or supervised by a military officer in India.

Not content with leading water into the cisterns of Fort St. George, Baker propounded a scheme in 1786 for watering ships at anchor

[1] *Madras Public Consultations*, Vol. XXII, August 19th, 1695.
[2] *Miscellaneous Letters Received*, Vol. LV, April 23rd, 1771.

outside the surf. He proposed to store more than 4,000 tons of fresh water in lighters moored beyond the surf. These lighters were to be supplied by a pipe from the Fort cisterns, or from special reservoirs on the beach, the pipe being laid either on the sea bottom or on a jetty. He entered into considerable detail in his report, which covered no less than 50 folio pages. "I have now not only to Wish But to Pray," he concluded, "that if what I have said be Vissionary or Illusive, It may, like other visions, Pass away. It has happened that even a Promising Child (I Don't say this is such) has been lost in the Hands of a Lukewarm Nurse. But I feel myself so unwell, and so unable to attend to the Subject, and finding it so Difficult to get any Body that Can Copy my Scrawl, And being therefore so little Pleased with what I have here Done, And Perswaded that any other Body must be less so, that I am afraid I shall not be able to write more; Or Rather No Body has much Reason to Fear that I shall again Pester them." Alas, the lugubrious Baker's promising child was lost in the archives of a lukewarm Government, and nothing more came of his scheme to water ships by a pipe-line.

Baker's schemes were concerned mainly with the supply of water to the Fort; but the supply to the native city of Madras soon demanded attention, although little was done to improve it for many years after Baker had gone. The impurity of the water from the hundreds of shallow wells scattered over this area was fully recognized. Many of the streets were mere passages and water-courses, winding here and there, and thick with liquid sewage which percolated into the wells. From 1855 to 1866 several large schemes for improvement were considered, but it was not till the latter year that the "Madras City Waterworks" were formed under the control of the Municipality to carry out a scheme at a cost of £128,000 for a town supply from a large reservoir at a place called Red Hills, some eight miles north-west of Madras. Water was first given to the city from this reservoir in May, 1872. City water-supplies were soon being undertaken all over India. A large scheme was carried out for Nagpur in the Central Provinces between 1869 and 1873, and another for Jubbulpore between 1877 and 1881. Lahore was given a piped supply in 1881, Karachi in 1884, and Delhi in 1892. Others were provided for Burdwan, Dacca, Mhow, Satara, Jalgaon, Pandharpur, Thana, Kolhapur, Secunderabad, Bangalore, Ootacamund, Wellington and Hyderabad (Sind), to mention a few only of the cities to which water was distributed before the close of the nineteenth century. Poona was one of the first to receive it: a project for the supply of that city and Kirkee was framed in 1866 by Lieut.-Colonel J.G. Fife, R.(Bo.)E., at a cost of 28 lakhs of rupees, and this was duly carried out. In 1884 Major A.J.C. Cunningham, R.(B.)E., was placed on special duty at Lucknow and framed three schemes—one for pumping from the Gumti, another for supply from a canal, and a

third for water from artesian wells—the system finally adopted, and opened in 1892, being for pumping from the Gumti. Again, in 1898, Captain A. T. Moore, R.E., prepared a wonderful scheme for the supply of the hill station of Murree. It was forwarded to Government by Lieut.-Colonel J. E. Broadbent, R.E., and the work was completed a few years later.

After the abolition of the Military Board in 1854, when the Public Works Department came directly under the Supreme Government, its operations were rapidly extended. These were interrupted, of course, by the Indian Mutiny ; but when the effects of that cataclysm had disappeared, the water-supply of cities and cantonments began to receive almost as much attention as the development of canals, railways and roads. For many years after the Mutiny, the Chief Engineers and most of the other senior engineers in civil employment were military officers ; while in some provinces, notably in Bombay, there were very few civil engineers until about 1875. In all provinces, the civil engineers were junior and inexperienced. Thus it was that most of the early schemes for water-supply were designed and executed by military engineers. The large modern schemes are the work of civil engineers. So many military engineers were concerned in the early schemes in various parts of India that it is impossible to mention the names of more than a few. The Royal Engineer has now almost vanished from the Buildings and Roads Branch of the Public Works Department, which deals with this type of engineering.

Most interesting and extensive schemes for water-supply were initiated many years ago for the city of Bombay. In ancient times the city had hundreds of tanks and wells, constructed by pious men for the public good to give water which was used for both washing and drinking. A private well within a house was considered a luxury, but many of the houses in the Fort were supplied in this way with water which percolated to the wells from the foul ditch which surrounded the ramparts. The rapidity with which Bombay was increasing in size and population, combined with a failure of the rains, caused the Government to appoint a " Committee of Tanks and Wells " in 1824 to relieve the scarcity of water. It was the scarcity rather than the impurity of the water-supply which underlay the efforts which were made by Government. In 1834 the population of Bombay was about 250,000 persons ; in 1850 it was 556,000, and in 1857 it had reached a total of 700,000. As far back as 1828, Major W. H. Sykes, of the Bombay Infantry, the " Statistical Reporter " of the local Government and afterwards Chairman of the East India Company, had suggested that surface water should be collected from the low hills near the city ; but no definite steps were taken until 1845, when the shortage of water obliged the Government to investigate all possible sources of supply. Various proposals were made, and Colonel G. R. Jervis, late Bo.E., the Chief Engineer

at that time, tried unsuccessfully to revive the plan suggested by Sykes. The Civil Architect, Captain T. M. B. Turner, Bo.E., wished to impound water on Malabar Hill and an adjacent height, but this plan was also rejected.

Captain J. H. Graham-Crawford, Bo.E., remarked in 1846 that the valley of the Goper, traversing the plateau of the adjoining island of Salsette, was obviously the only natural and sufficient source of supply from surface collection, yet the valley was so distant, and the cost so prohibitive, that his suggestion fell on deaf ears. Then came the water-famine of 1851, when Lieutenant (afterwards Major-General) Alfred de Lisle, Bo.E., was ordered to make a preliminary survey of the Goper Valley and reported that there were five admirable sites in that region for storage reservoirs, two of which, the Vehar and Powai, were basins of large size. In 1852, Mr. H. Conybeare, a civilian engineer, was appointed to investigate the possibilities of this region, and in 1855, guided by Crawford's and de Lisle's reports, he elaborated a great scheme for the construction of the Vehar Lake. Another water-famine in the previous year had been so serious that railway and country boats were used to carry water from the mainland to Bombay City, but the Vehar Dam was finished in May, 1856, two others in 1858, and in March, 1860, the delivery of water to Bombay began through a 32-inch main nearly 14 miles in length. The Vehar Project, and its subsequent developments, cost £650,000.

Bombay, however, continued to expand so rapidly that it was soon evident that the Vehar supply would be unable to cope with the demand, so parties were sent out in 1868 to study and report on favourable sites for further reservoirs not only on Salsette but also on the mainland. In June, 1870, Captain Hector Tulloch, R (M.)E., the most prominent military engineer in the history of the Bombay waterworks, was directed to submit a project for a reservoir at Tulsi, near the celebrated cave-temples of Kennery in northern Salsette, as other projects for reservoirs at Shewla, Kennery and Powai had not found favour. The Tulsi works, on Tulloch's design, were begun in 1872 and completed in seven years, and with the Vehar supply provided 14,000,000 gallons a day. Still Bombay continued to expand, and by 1884 more water was needed, so reservoirs were made at Bhandarwada and on Malabar Hill. The earlier surveys had shown that a site for an enormous reservoir existed on the mainland below the spurs of the Western Ghats on the Tansa River. Plans and estimates, based on a project devised originally by Tulloch,[1] were prepared accordingly in 1885, the work was put in hand, and on March 31st, 1892, at a cost of £1,500,000, the Tansa Lake began to deliver water to Bombay. This lake, which lies about 55 miles

[1] Full reports by Major H. Tulloch, R.E., on the Vehar, Tulsi, Tansa and other projects, can be seen in *Professional Papers on Indian Engineering, 2nd Series,* Vol. II, 1873.

north-east of the city, has a waterspread of nearly seven square miles. The Tansa, Vehar and Tulsi Lakes have a combined storage capacity of more than 30,000 millions of gallons, and their design, if not their construction, was largely the work of military engineers. Extensive developments of the Bombay water-supply have taken place in the present century, but this brief sketch is sufficient to show that soldiers took a considerable share in the early schemes.

The name of Captain (afterwards Major-General) J. W. Playfair, Bo.E., is associated with a peculiar system of water-supply at Aden, the Gibraltar of the East. This dry outpost of the Indian Empire now has an artesian well supply from Sheikh Othman which can yield 100,000 gallons a day, but in the middle of the last century the position was not so satisfactory. The highest peak of the rocky heights which surround the old crater in the centre of Aden is more than 1,700 feet above the sea. On the eastern side, the ravines dividing a number of forbidding precipices converge into a chasm winding down towards the town on the crater floor, and in very ancient times a series of cisterns, or tanks, which legend ascribes to the Queen of Sheba, was made in this cleft to catch the meagre and uncertain surface drainage. Playfair turned his attention to these tanks, most of which were buried or concealed, and in 1854 undertook the task of restoring them. As the work progressed, the size of the ancient system was revealed. New tanks came into view, and when Playfair left Aden in 1857, the tanks already excavated could store 3,500,000 gallons. Each was given a concrete lining overlaid with lime plaster. Captain (afterwards General) J. A. Fuller, Bo.E., carried on Playfair's work, and when the project was completed a few years later, the tanks, and some upper lakes formed by dams, could hold 11,000,000 gallons. Water was obtainable also from wells sunk to great depths in the solid rock, but it was often brackish and usually impure, so the tank and well-supply was supplemented afterwards by an elaborate and costly installation for distilling sea-water. The modern artesian-well system has solved the problem of the Aden water-supply, but Playfair's system may still prove valuable in an emergency.

We turn now to Calcutta, the former capital of India. No more insanitary spot existed in the very old days. The Directors wrote in 1709 that their agents in Bengal should be careful to drain the ground and fill up all tanks. "Standing Water," they remarked,[1] "contributes to the unhealthyness of the Place and Subjects People to Agues, ffeavers and ffluxes, and no wonder for it has the same Effect in England. We are inform'd the greatest part of the Standing Water is occasion'd by the Peoples digging the Earth to make their Houses with, and then in the next Rains the Holes are fill'd

[1] *General Letter, Court to Bengal,* February 4th, 1709. Letter Book No. 13.

with Water which there Stagnates and corrupts." Seventy years later, according to William Mackintosh,[1] there was "not a spot where judgement, taste, decency and convenience are so grossly insulted as in that scattered and confused chaos of houses, huts, sheds, streets, lanes, alleys, windings, gutters, sinks and tanks, which, jumbled into an undistinguished mass of filth and corruption equally offensive to human sense and health, compose the capital of the English Company's Government in India." Lord Wellesley tried to cleanse Calcutta by establishing a Town Improvements Committee in 1803, but in 1814 the Committee was replaced by a peculiar body known as the "Lottery Commissioners," who raised funds by lotteries to pay for many improvements, including those to the roads, water-supply and drainage. This was not a success. In 1820 the streets were still unmetalled, and the air was poisoned by the foul open drains alongside them. Matters then began to improve slowly, yet in 1864 the Sanitary Commission of Bengal recorded that,[2] "If a plain unvarnished description of the streets of the Northern Division of Calcutta, bordered by their horrible open drains, were given to the people of England, they would consider the account altogether incredible." They added that the city was literally unfit for the habitation of civilised men. These were the conditions confronting some of the military engineers who laboured in the early days to drain and water the city.

Lieutenant J. A. Schalch, of the Bengal Infantry,[3] recommended in 1821 that large masonry sewers should be constructed from the Hugli River to a proposed circular canal to carry all the sewage and surface drainage of the city into the Salt Lakes, but nothing more happened until about 1836, when a body known as the Fever Hospital Committee stated that an underground system was essential. They were opposed by Captain James Prinsep,[4] Assay-master to the Calcutta Mint and brother of Captain Thomas Prinsep, B.E., who maintained that the lack of a constant flow of water through the proposed drains would make them dangerous to health. James Prinsep had seen a sewerage system tried at Benares and proved to be a failure. Then Captain George Thomson, B.E.,[5] who was employed on canal work and had thought much about the drainage of Calcutta, recommended an elaborate network of underground drains or sewers, flushed partly by river-water and partly by water from the Entally Canal; but the Fever Hospital Committee were more attracted by a scheme submitted by Captain (afterwards Major-

[1] *Travels in Europe, Asia and Africa*, by W. Mackintosh, 1782.

[2] *Municipal Calcutta*, by S. W. Goode, p. 28.

[3] Schalch prepared a valuable map of Calcutta in 1825.

[4] James Prinsep was a capable engineer. He built a Mint and church at Benares, bridged a river, and completed a canal between the Hugli and the Sundarbands (below Calcutta) which had been begun by his brother Thomas.

[5] "Thomson of Ghazni" in the 1st Afghan War of 1838–39. (See Vol. I, Chapter XV.)

General) W. N. Forbes, B.E.,[1] who proposed to build a large masonry aqueduct from the Hugli at the old Chitpore Bridge to the old Park Street cemetery, communicating with the Salt Lakes by a wide open canal nearly parallel to the Entally Canal. For many years, however, all such schemes were shelved for lack of money. Yet when Mr. William Clark, the first Engineer to the Calcutta Corporation, revived the question in 1855, he referred to Forbes' scheme as the only plan approximating to completeness which had been proposed for the drainage of Calcutta, although the altered conditions had by then rendered it impracticable. The project which Clark himself submitted was based largely on Schalch's plans and levels and on the data collected by Forbes, and thus the work of some of the early military engineers was not wasted. Clark's scheme was sanctioned in 1859 at a cost of 34 lakhs of rupees, and included 30 miles of brick and nearly 80 miles of pipe sewers. Sixteen years elapsed before the main sewers were finished, and the installation was completed about 1890. This sketch of the history of one of several large drainage undertakings in India is given to illustrate once more the variety of the employment of the early military engineers before they were supplanted by their civilian brethren. An infantryman, an assayer, a canal expert and a builder, all had a say in it, but this was in pre-Mutiny days.

The water-supply of Calcutta has been connected intimately with its drainage. The elaborate drainage works initiated by Clark in 1859 made proper conservancy possible at last, and the Corporation could then attack the problem of water distribution, but in contrast to Bombay, military engineers had little concern in it. Those who were left in Calcutta retired into their shell—Fort William—or occupied the seats of the mighty in Secretariats: the others went farther afield. In the earliest times the situation was different. Calcutta was then dependent for its pure water-supply on tanks and wells, and particularly on the Lal Dighi, the great tank in the present Dalhousie Square adjoining the site of Old Fort William. This tank was deepened and extended in 1709 by the Gunners, ships' captains and other adventurous amateur engineers of the day, to supply the old fort and the European houses around it,[2] and many private tanks were excavated in the native city during the remainder of the eighteenth century when military engineers were in control. Between 1805 and 1836, the Town Improvements Committee, the Lottery Commissioners and the Lottery Committee in turn began to direct their attention seriously to water-supply, and with more success than with drainage. Tanks were dug in Cornwallis Square, College Square, Wellington Square, Wellesley Square, and other places, and a small pumping plant was set up in 1820 at Chandpal

[1] Forbes designed and built the Calcutta Mint, and designed St. Paul's Cathedral at Calcutta.

[2] See Vol. I, Chapter III.

Ghat to raise water into open masonry aqueducts; yet the Fever Hospital Committee reported in 1836 that good tanks and clean wells were rare. The poorer Indians used tank or well-water, and drew water from the Hugli between October and March, when it was not saline or turbid. The richer Indians imported drinking-water from outside. The Europeans often used rainwater, which they stored in Pegu earthenware jars. The water for soda-water came from the Lal Dighi Tank, and the only purifying process was filtration through a bed of sand and charcoal after a red-hot iron had been immersed in each jar of water "to destroy the animalculæ"! It seems that our countrymen had great faith in the hot-iron treatment, for Calcutta water was often supplied to "persons proceeding to sea," and one lady, who took a stock of it with her to England, wrote from Liverpool that her remaining bottle of it "was not surpassed in either sweetness or transparency," these being apparently the only tests of purity.[1]

The need for good water was explicitly recognized by the authorities in 1848, and from the time of Mr. Clark's appointment in 1854 it was considered very seriously. Clark wanted a proper underground system of cast-iron pipes in place of surface aqueducts, but for some years he was too busy with his drainage schemes to devote much attention to water-supply. In 1865, however, he submitted a complete scheme to supply 6,000,000 gallons a day to a population of 400,000 persons, the water being pumped from the Hugli at Pulta and then filtered. This project was completed about 1870, and in later years the system was remodelled and extended. In 1911 a gravitation supply of filtered water was opened from a gigantic elevated reservoir at Tallah outside Calcutta to supplement another system of unfiltered water. This steel reservoir—at that time the largest in the world—holds 40,000 tons of water (9,000,000 gallons); its floor is nearly 100 feet above the ground, its depth 16 feet, and each of its sides more than 100 yards in length. This masterpiece was the work of a civil engineer, Mr. W. B. MacCabe, so it has no proper place in this story, but it emphasizes the advance of engineering in India during the last century. The water-supply work of military engineers in Calcutta has been confined mainly to projects for Fort William. These have been extensive, as have others in a number of military cantonments scattered over the length and breadth of India; but they do not call for special remark, nor do they compare in size and importance with the schemes originated by military engineers for the supply of Bombay.

Water is a good servant, but a bad master, and many a Royal Engineer has had to combat at short notice the idiosyncrasies and vagaries of the rivers of that land of emergencies, India. Normally this duty comes chiefly within the province of the irrigation engineer,

[1] *Municipal Calcutta*, by S. W. Goode, p. 182.

but the bridge builder has much to do with river-training work, and occasionally a special officer may be appointed to limit the damage done by an unusual flood where no engineering work is in progress. Such was the crisis which arose in 1894 in the Gohna Valley in Garhwal, south of the three Himalayan peaks of Trisul and 5,500 feet above the sea, when Lieutenant (now Major-General Sir Sydney) Crookshank, R.E., was placed in sole charge of the flood protective measures necessitated by one of the biggest landslides of all time. A mountainside had descended bodily into the valley, making a natural dam 800 to 1,000 feet in height, one mile across, and extending for three miles upstream. Behind this stupendous mass, a lake formed slowly for a distance of five miles up the valley, rose to the top of the dam, and then cut through it in a channel 350 feet deep, hurling an avalanche of water down the gorge below. Yet it is a fact that, largely owing to Crookshank's exertions, not a life was lost. "I had a very rickety Berthon boat," he writes,[1] "and it was difficult to take soundings of any depth. The lake, while filling to a maximum depth of 850 feet, sometimes rose as much as three feet in a day when the snow was melting, and afterwards the flood was nearly 150 feet deep at Chamoli, where the valley widens out 13 miles below the dam." This emergency was met successfully by a young Sapper officer of only five years' service and with no previous experience in flood control. It deserves more than passing notice in a chapter devoted to the supply and control of water.

Cheap motive power is one of the secrets of successful industrial development, and India is rapidly becoming one of the leading countries of the world in harnessing water to generate electrical power. Coal and oil are scarce except in a few areas ; the coalfields, for example, are mostly concentrated in Bengal and Chota Nagpur. Hence the solution of a difficult problem seems to lie in water power. But although the seven great rivers eastward from the Indus are said to be capable of giving 3,000,000 horse-power for every thousand feet of fall from the Himalayas, their volumes alter according to the season of the year, while the demand for power remains constant. The same difficulty is met in other parts, so the majority of water-power schemes for India must provide for storage in mountainous regions where the rainfall is heavy. One of the largest of such undertakings is the group of the Tata hydro-electric installations which serve modern Bombay, and for these the city is indebted to a great extent to the energy and foresight of a distinguished Royal Engineer, the late Baron Sydenham of Combe, G.C.S.I., G.C.M.G., G.C.I.E., G.B.E.,[2] who, as Colonel Sir George Sydenham Clarke, was Governor of Bombay from 1907 to 1913. He showed such interest in the first Tata scheme that money flowed in to form a company for its execution,

[1] Letter from Major-General Sir Sydney Crookshank, K.C.M.G., C.B., C.I.E., D.S.O., M.V.O., to the author, dated March 10th, 1933.

[2] Lord Sydenham died in February, 1933. See Chapter XVII.

and it was opened in February, 1915. This installation has a power-house at Khopuli at the foot of the Bhor Ghat, and the water stored in three reservoirs is capable of generating 40,000 electrical horse-power for Bombay City and its numerous mills and manufactories. Since the Great War, the Andhra River extension[1] has developed the original scheme towards the north, and the Nilla and Mulla Rivers extension[2] has been added southwards ; other extensions have also been completed or are in hand. In these post-war activities Lord Sydenham had no part, but it was due no doubt to his influence and engineering knowledge that the original Tata project was launched after years of discussion and carried to a successful conclusion.

Bombay was late in entering the field of hydro-electric engineering. The first scheme undertaken in India, and indeed in the East, was that on the Cauvery River in Mysore, where Sir Arthur Cotton began his rise to fame ; and the man who imagined it, began it and carried it through was Captain A. C. de L. Joly de Lotbinière, R.E.[3] The scheme consisted in utilizing part of the great natural power running to waste at the Cauvery Falls, 62 miles south-west of Bangalore, and applying it to driving the mining machinery, stamps, crushers, air-compressors and pumps of the Kolar goldfields. The initial undertaking provided for only 6,000 electrical horse-power, but more than seven times that amount is now developed. The idea of using the power of the Cauvery for commercial purposes was not new. It had been suggested several times, but the falls are so isolated that it seemed that there would be no demand for power in their vicinity. Many of the problems of long-distance transmission had not then been solved, and it was only when the value and practicability of employing alternating currents at a high voltage was clearly recognized and proved that business men were prepared to accept the proposition and finance the venture.[4]

The history of the birth of the Cauvery hydro-electric scheme, at that time the longest proposed transmission line in the world, is best told by General Joly de Lotbinière in his own words :—[5]

" My excuse for writing this story of the inception and carrying out of the transmission of electrical power from the Cauvery Falls to the Kolar Gold Fields of Mysore is that Lieut.-Colonel E. W. C. Sandes, D.S.O., M.C., the author of *The Military Engineer in India*, has asked me to write it, and that it offers me an opportunity to

[1] The Andhra River scheme includes a dam, 192 feet high, which holds up a lake nearly 12 miles long. By the pressure obtained through a drop of 1,750 feet, 100,000 electrical horse-power can be generated.

[2] The Nilla-Mulla scheme can generate 150,000 electrical horse-power at 11,000 volts. This is transformed to 110,000 volts for transmission over 80 miles of overhead line to Bombay.

[3] Now Major-General A. C. de L. Joly de Lotbinière, C.B., C.S.I., C.I.E.

[4] Details of the Cauvery Falls Electrical Power Scheme are given in the issue of *The Engineer* dated June 6th, 1902, pp. 553–556 and pp. 576–578.

[5] Extracts from notes sent to the author on January 12th, 1933, by Major-General Joly de Lotbinière.

place on record the wonderful foresight, acumen and fearlessness of one of India's leading statesmen, Sir K. Sheshadri Iyer, who was Dewan (Prime Minister) of the Mysore State in 1898. In that year I was serving at Chatham when I received a cable from Sir Sheshadri inviting me to return to India as Deputy Chief Engineer of the Mysore Public Works, and I was allowed by the Home authorities and the Government of India to accept the appointment. On my arrival in Mysore, I called on the Dewan and asked him why he had selected me. He replied, 'When you worked for the Government of India, you fought me hard in the interests of your Government. Now I wish you to do the same for me and my Government.' His Highness the Maharajah being at that time a minor, Sir Sheshadri was Prime Minister and Her Highness the Maharani (mother of the Maharajah) was Regent.

"Some months after I had joined the service of the Mysore Durbar (Government) I visited the Kolar Gold Fields, and in conversation with various Superintendents of Mines, I gathered that the Fields spent many lakhs of rupees monthly on coal. I had heard of the falls of the Cauvery, the largest river in Southern India, so I visited them and was immediately struck by the vast power running to waste in the jungle, 100 miles from any place where it could be utilized. It was impossible to build any manufactories close to the falls, as malaria had driven away the inhabitants of the adjacent town of Sivasamudram, which lay deserted and was fast being swallowed up by the jungle. As I looked at the falls I remembered that American engineers had harnessed Niagara and were transmitting power over a distance of 28 miles to Buffalo. If this could be done in America, why not for 100 miles in Mysore to the Kolar Gold Fields, where a splendid market existed for day and night supply throughout the year? I there and then determined to investigate the possibility.

"Returning to Bangalore, I read up every book I could find dealing with the transmission of power, and eventually came to the conclusion that it was possible to carry out my idea. Before going any further it was clearly necessary to obtain the permission of the Dewan, Sir K. Sheshadri Iyer, to undertake a full investigation of the subject; and he being then at Ootacamund in the Nilgiri Hills, I went there with the permission of the Chief Engineer, Colonel D. McNeil Campbell, late R.E., who fully entered into my proposals, and explained my ideas to Sir Sheshadri. I shall never forget that interview. The Dewan was sitting at his office desk, and I stood beside him. I opened the conversation by saying, 'Sir Sheshadri, you have no coal in Mysore, but you have an endless mine of white coal in the foam of the Cauvery Falls.' He looked at me and said, 'What can you do with that power?' I replied, 'I can spread it throughout your State.' Jumping up from his chair, and putting his

hands on my shoulders, he gazed intently at me and said, ' All my life I have felt that some day an Englishman would say that to me. I give you *carte blanche* to carry out the scheme.' And thereafter that great statesman never doubted for an instant that the work could be executed."

To ensure that the results of previous experience fully authorized the contemplated expenditure, Joly de Lotbinière was sent to America to inspect the transmission schemes in the United States and Canada, and he came to the conclusion that the Cauvery Falls project was feasible, though involving transmission over a greater distance than that at Redlands, Los Angeles, at that time the longest transmission line in the world. He had instructions to obtain estimates from the leading manufacturers of electrical plant in Europe and America, and to get the expert opinions of Professors Forbes and Unwin. After seeing what had been accomplished in Switzerland, Canada and the United States, Joly de Lotbinière, acting for the Mysore Government, gave the contract for all electrical plant provisionally to the General Electric Company of Schenectady, New York, and for the remaining plant to other firms. Lord Curzon, the Viceroy, had already approved of the attempt being made to harness the Cauvery, as there seemed to be a reasonable prospect of success. The stage was set for a great undertaking.

General Joly de Lotbinière takes up the tale :—

" When I returned to India with the various contracts for the formal approval of the Mysore Durbar, I found Sir Sheshadri Iyer very ill and confined to his bed. However, he sent for me, and when I entered his room with the papers he felt under his pillow and produced a letter, which he handed to me. This begged him that, before it was too late, he would not imperil his splendid record and the finances of his Government by permitting me to carry out such an expensive and problematical undertaking. My heart sank into my boots. Sir Sheshadri then asked, ' Have you got your stylo pen with you ? ' I produced it. ' Give me the documents,' said he. " I will now show how I am going to *ruin* my country.' And there and then he signed all the papers and lay back exhausted on his pillow. Until he died, he never wavered in his determination to see the undertaking completed, but, alas, he was not to live to see the end. To-day, the enlarged installation distributes power through a network of lines throughout the Mysore State. The original installation, far from ruining the finances of the country, repaid in the first five years the whole of its capital cost of £500,000, together with the operating expenses and 4% interest on the capital outlay. The gold mines, when operated by steam, spent £31 annually on every horse-power, whereas, after the first five years with electrical power, the cost per horse-power was reduced to £10, enabling the mines to carry on to their present depths of over 6,000 feet."

The Cauvery Power Scheme, which cost £340,000,[1] was opened in June, 1902, after nearly two years had been spent in constructing the riverworks, channels, power and transformer stations and overhead line. The nearest railway station was 30 miles away, and the transport difficulties were considerable, as no traction engines were procurable in India. Elephants and bullocks were employed to haul the plant, parts of which weighed 14 tons. On steep slopes, the bullocks pulled in front while two elephants pushed behind. Five thousand labourers were sometimes engaged on the work, and there was great trouble at first in collecting and keeping them at the site of the headworks on the river. This puzzled the engineers, until they discovered that the labourers believed that the god of the Falls was very angry at the idea of any of the river-water being diverted, and had informed the people, through a fakir, that anyone assisting in the undertaking would die forthwith. It so happened that malarial fever was very prevalent at the time, and when cholera broke out, all the workmen vanished into the jungles. It was only with the greatest difficulty that others were procured on the assurance that the new god, being imported in the shape of machinery, was much stronger than the old one who guarded the Falls. These alarms and excursions are all in the day's work in India.

The success of the Cauvery installation had an immediate effect. The Kashmir Government began to realize fully the value of the power running to waste in its rivers, and as wood was scarce and coal almost unobtainable, decided in 1903 to examine the possibilities of hydro-electric generation. The northern rivers of India, though variable in their discharge, are less so than the rivers of the south, because they are filled in the dry season by the melting snows of the Himalayas. It was obvious to the Kashmir Durbar that if a southern river such as the Cauvery could be made to generate power all the year round, excellent results should be obtainable from the more favourably-situated waters of Kashmir, so the Durbar invited Major Joly de Lotbinière, C.I.E., R.E., to visit them and draw up a scheme for water-power. Arriving from Mysore in September, 1904, Joly de Lotbinière considered the suitability of various sources of power in and about the Kashmir Valley, and decided in favour of the Jhelum River as it promised an almost inexhaustible supply. Fed by glaciers, and draining a large area of the north-western Himalayas, it delivers never less than 5,000 cubic feet per second. Careful reconnaissance along its course disclosed the fact that at Rampur, 21 miles below Baramulla on the Jhelum Valley Road and about 55 miles from Srinagar, a head of 400 feet could be gained in 6½ miles by running a duct or "flume" along the side of the ravine at a slope less than that of the river.

The scheme which Joly de Lotbinière submitted included the

[1] *History of the Cauvery Power Scheme*, by M. Gopalkrishnaiya, 1932, p. 96.

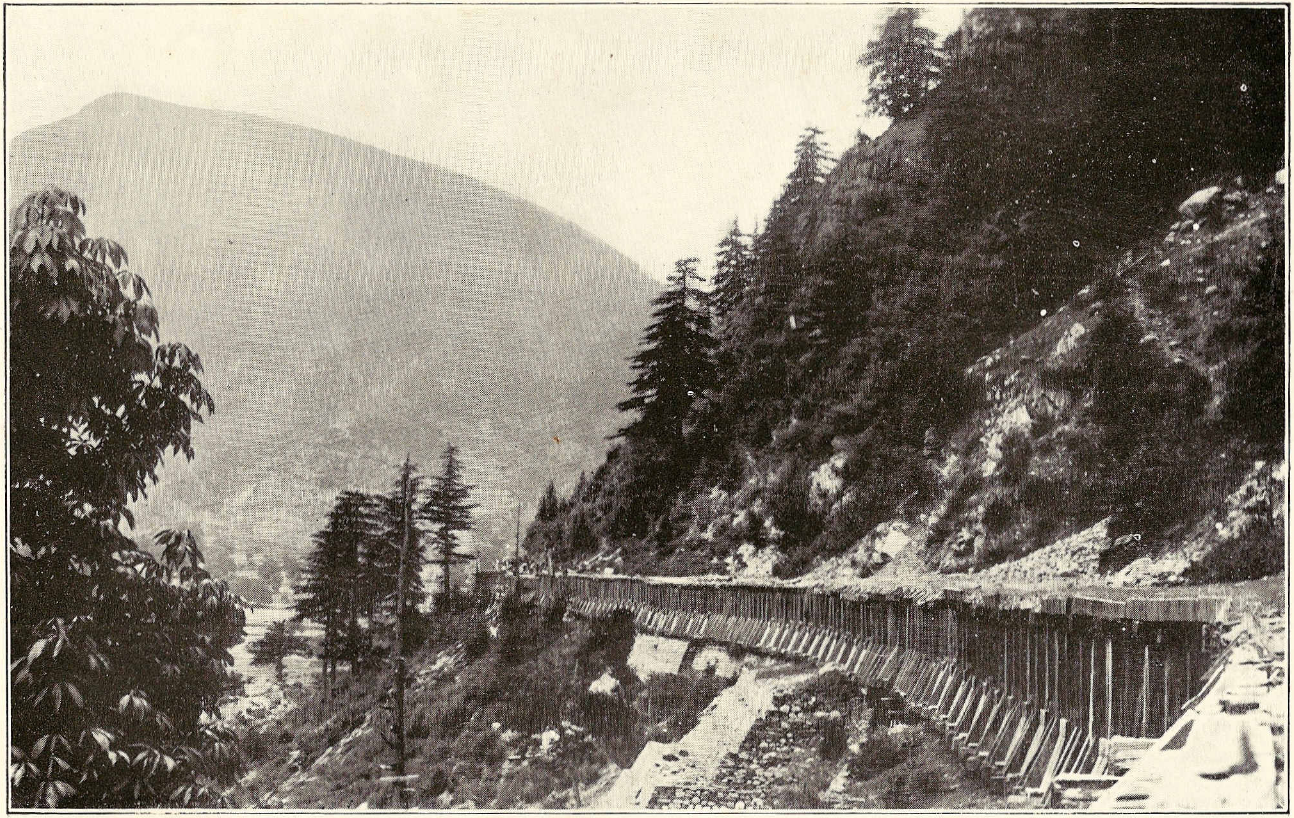
construction of this flume, which was designed to carry enough water to generate 20,000 electrical horse-power at the power-house below its end, although it was decided to limit the initial output to 5,000 horse-power. The flume is the most interesting feature of a fine undertaking. Wherever possible it is of masonry in deep cutting, arched over and buried ; but for two-thirds of its length it is of thick wooden planking held together by wooden frames at intervals. With a cross-section about eight feet square, giving a maximum discharge of 500 *cusecs*, it is one of the largest of its kind in the world. It tunnels through six projecting spurs, crosses six torrents by bridges, and allows five other torrents to pass over it.[1] The Kashmir Durbar wished particularly to get electrical current to operate dredgers on the Jhelum between Baramulla and the Wular Lake, and also to supply heat and power to a huge silk factory at Srinagar. The Jhelum above Baramulla has a small slope and is liable to silt up and overflow, and Joly de Lotbinière came to the surprising conclusion that these periodical floods were caused by *goats*. Many thousands of these animals were allowed to graze on the hills around the valley, and in so doing denuded the steep slopes of herbage and loosened vast quantities of stones and gravel. These were washed into the valley by heavy rain, obstructing the water-courses and blocking the outfall of the river below Baramulla. Hence the floods, hence the dredgers, and hence in part the hydro-electric scheme.

The Kashmir Durbar sanctioned the scheme in March, 1905, and the electric plant was ordered, as in Mysore, from the General Electric Company, while other firms supplied the remainder.[2] It was decided to transmit at the high pressure of 60,000 volts along a double line to Baramulla, followed by a single line to Srinagar, although so high a voltage had not hitherto been tried in the East. Altogether, the Jhelum installation, in a remote part of India and 150 miles from the nearest railway station, was in many respects unique, and its successful completion in 1908 added to the reputation of Major Joly de Lotbinière, Lieutenant J. C. Hunter,[3] his Resident Engineer, and the staff who assisted them. For 20 years after the scheme came into operation, the Jhelum was deepened annually below the Wular Lake by several electric dredgers. Srinagar, Baramulla and other towns were supplied with current for lighting and machinery, and the State silk factory came to be operated entirely by electrical power. The electrification of part of Kashmir was due to the foresight and progressive policy of the late Maharajah, His Highness Sir Pratab Singh, G.C.S.I., and to the imagination, knowledge, self-reliance and energy of a Royal Engineer.

[1] A description of the scheme is given in an article entitled "The Jhelum Hydro-Electric Works," appearing in the issue of *The World's Work* dated November, 1907, pp. 666–673.

[2] The generators were 1,000 kilo-watt, 3-phase, 2,300-volt, 25-cycle type, and the waterwheels of tangential type.

[3] Hunter had occupied the same responsible post on the Cauvery.



FLUME AT CHANANWARI, MOHORA, KASHMIR. JHELUM HYDRO-ELECTRIC INSTALLATION.

On March 10th, 1933, near the famous Shalamar Garden at Lahore, Lord Willingdon touched a silver switch which energized the 16,000 horse-power turbines of the Uhl River Hydro-Electric Scheme, 180 miles away, and sent current through 400 miles of transmission lines to 14 towns scattered over a part of the Punjab which is six times the size of Wales. In extent and capacity this scheme almost rivals the Tata undertakings near Bombay. It transmits energy at 132,000 volts, which is equivalent to that of the new grid system in England; it develops power at 36,000 kilo-watts and is capable of ultimate extension to 112,000. The waters of the Uhl and Lambadag Rivers, tributaries of the Beas, north-west of Simla, have been taken by pipes through a spur of a mountain range down to the Rana tributary at Jogindar Nagar, a drop of 1,800 feet. The tunnel which holds the pipes—the first steel-mantled tunnel to be built in Asia—is $2\frac{2}{3}$-miles in length and has been bored through quartz and granite. These are a few only of the outstanding features of a remarkable project which will always be connected with the name of a Royal Engineer—the late Colonel B. C. Battye, D.S.O., one of the "Fighting Battyes" of India.

Basil Battye was serving in India in 1907 when he was sent to England for an Electrical and Mechanical course. On his return, his great knowledge of electrical work led to his appointment to the charge of the Simla Hydro-Electric Scheme, the first of its kind in the Punjab, and from start to finish he directed that undertaking. This, however, was only the forerunner of the much larger task on the Uhl River which he was destined to face after the Great War. His war record in France was distinguished,[1] but he preferred the civil to the military engineering side of his profession, so in October, 1919, he was engaged once more in hydro-electric work for the Punjab Government, and in 1921 produced a scheme for an 80,000 kilo-watt installation on the Sutlej.[2] This site was discarded in 1922 in favour of one on the Uhl River,[3] and there, with an expert military and civilian staff, Battye began the crowning exploit of his life. Alas, he was not to see its end, for he was killed in a motor accident on May 16th, 1932, only ten months before the Viceroy opened the installation. Had he lived, a great career would certainly have been his. He died in harness, which is a way the Battyes have. His father and three uncles were killed in action between the Indian Mutiny and the Relief of Chitral in 1895, and of his

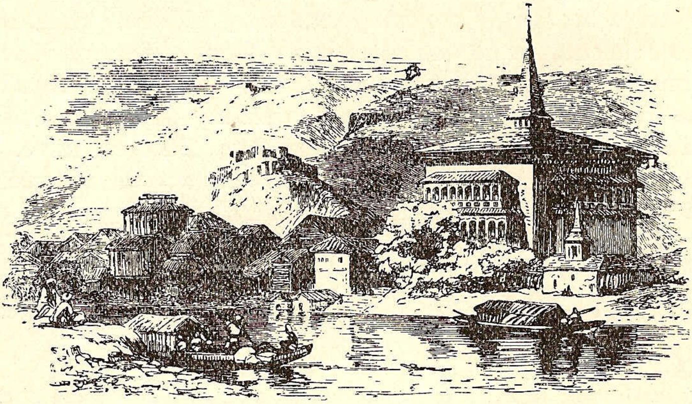
[1] See the Memoir of Colonel Basil Condon Battye, D.S.O., late R.E., which appears in *The R.E. Journal*, December, 1932, pp. 699–703.

[2] Full details are given in a Government publication entitled *The Sutlej River Hydro-Electric Scheme* (1921), by Bt. Lieut.-Colonel Basil C. Battye, D.S.O., R.E., A.I.C.E., A.M.I.C.E.

[3] One of Battye's most capable assistants, Major Aylward, D.S.O., M.C., A.M.I.C.E. (a railway engineer) is said to have had a hand in selecting the Uhl River site. Captains A. Guthrie, R. D. Keane, N. Boddington, H. A. Kenyon, and F. E. Pool, R.E., also assisted Battye on the work. They may be called "the last of the Mohicans."

brothers, one was killed in the Tirah in 1897 and another in Gallipoli in 1915.

In January, 1928, the boring of the great Dhauladhar tunnel from the Uhl River reservoir site was begun on both sides of a mountain spur 2,600 feet high, and when the two drifts met at last on March 1st, 1932, it was found that the error in direction was less than one inch in a distance of 14,200 feet, and this despite the fact that the tunnelling operations had been hampered by falls of rock and the inflow of water. Before a branch line of railway was built, the difficulties of transport up the narrow and winding Kangra Valley to the site of the headworks were considerable. Rail-head was then at Pathankot, 90 miles away, and some of the articles to be transported by lorries were very heavy, for instance the cables for haulage-ways, which weighed 9½ tons each. A haulage-way to carry 15 tons was built up the hillside from Jogindar Nagar to the tunnel-mouth, and two smaller ones were erected to connect the tunnel ends. A light railway had to be built at a height of over 8,000 feet, and the cold was so great in winter that an "Arctic" gang of 50 selected men was formed to carry on the work in the snow and ice. Houses, roads, water-supply and drainage were provided for 5,000 people. The Uhl River Scheme promises to open up a new era of prosperity for the Punjab and the neighbouring States, just as the Ganges Hydro-Electric Scheme, designed and executed by Mr. W. L. Stampe, C.I.E., I.S.E., between 1927 and 1931, has done for the United Provinces. "It is with a feeling of great pride," said Lord Willingdon at Lahore, "that I can claim that security from famine, and great power schemes for industrial expansion, have been largely produced through the brains and engineering skill of my countrymen or by men coming from British stock." And with these words this sketch of a few of the hydraulic achievements of military engineers in India may be brought to a close.



SRINAGAR, THE CAPITAL OF CASHMERE.

CHAPTER IV.

NORTHERN ROADS.

WHEN Queen Victoria came to the throne, roadways in the modern sense were practically unknown in India outside the large towns. Yet to-day the country is crossed and recrossed by broad highways, and in the richer and more thickly populated areas there is hardly a town or city which is not connected directly with all its neighbours. That such a change should have occurred in less than a century is a lasting tribute to British administration. The roads which traverse the wide plains and thread the mountain passes of modern India are not of the superfine quality which makes those of England the best in the world ; but they fulfil their purpose, which is to open up the country and to serve enormous territories cheaply and effectively. They encourage trade, they simplify administration and they supplement the railways. But in the early period of British rule in India, the idea of providing facilities for wheeled traffic outside the cities was hardly considered. The plains of India are crossed by streams which, for eight months in each year, offer no obstacle to pack animals, so the traffic in those days was destitute of wheels. Caravans plodded along the dry and dusty " fair-weather " roads or tracks between trade centres ; and when the rains came, and every stream became a raging torrent and the country a dreary swamp, all traffic ceased.

Metalled roads, under such conditions, would have been a luxury ; bridges, a folly. Except in flood-times, the large rivers could be crossed by ferries and the small ones forded. Any well-marked track was good enough as a road. " From a military point of view," writes Chesney,[1] " this state of things had its advantages. The want of roads taught Indian armies how to do without them. All the subsidiary military establishments were framed on a scale and plan to admit of the troops moving readily across country in any direction. On the breaking-out of war, nothing had to be improvised, and the troops took the field without difficulty and confusion. This explains the extraordinary promptitude with which the wars of the Indian Army have so frequently been entered on, and, in some measure, the complacency with which the older school of Indian statesmen regarded the absence of any progress towards the improvement of the country."

[1] *Indian Polity*, by Lieut.-Colonel George Chesney, Royal (late Bengal) Engineers, p. 362.

The Mughal emperors gave some attention to road-construction before the British arrived, and in particular to certain trade routes such as those from Mirzapur southwards, from Agra to Ajmer, from Allahabad to Jubbulpore, and from Delhi by Agra to Allahabad, by Bareilly and Benares to Patna, and to Aligarh. They marked these wide unmetalled thoroughfares by *kos minars* (pillars), and by defended posts at intervals, and often planted trees alongside them. It is doubtful, however, whether they even considered the construction of permanent roads as we know them, although they built a number of bridges near large cities, such as the old masonry structure over the River Gumti at Jaunpore. Their bridges were massive barriers of brick or stone, resting on a solid floor and perforated with a number of small pointed arches which were quite incapable of passing any considerable flood. The Mughal ideas of bridge design were, in fact, as elementary as they were faulty, and the British learned nothing from them.

In Assam the Hindu rulers of the country seem to have launched out into ambitious schemes for unmetalled roads, not because they wished particularly to do so, but because they were goaded to action by the overwhelming floods of the Brahmaputra. Their roads, called *allees*, were constructed both as highways above flood-level and to control the inundations. One of them, the Bor Allee, which was begun by Rajah Rudru Singh in the middle of the eighteenth century, had a huge embankment, 40 feet wide at the top and many miles in length. In the course of this work, Rudru Singh's native architect had to build a road bridge with four large openings; but he completed no more than one because the Rajah, being pleased with his architect's work, feared that the latter might take service with the British, so he caused him to be strangled. Traces of old native highways exist in Bengal, Mysore and other parts of India, and these indicate that none of these roads was metalled and that few had any bridges. In the eighteenth century, the British were prepared to accept the roads as they found them; they had little money to spare for the improvement of trade routes in the interior, and their sphere of influence did not extend far from the coast. They contented themselves, at least in Northern India, with surveying and tabulating the native routes.[1]

British roadmaking in Northern India started from Calcutta, and it was begun by military engineers as there were no others. It seems that, about the year 1818, spasmodic attempts were made to improve the native tracks in Bengal by convict labour, but even as late as 1830 the roads were in no better state that in the time of the Mughals, except within 20 miles of Calcutta. Mails were still carried up-

[1] About the year 1775, for instance, the East India Company issued a *Book of Roads in Bengal and Bahar*, to which Major James Rennell, B.E., Surveyor-General in Bengal, added in 1778 a route book called *A Description of the Roads in Bengal and Bahar*.

country by runners, and it was only when in later years the inconvenience of this slow method began to be felt seriously that the British undertook extensive roadwork. Goods could be carried cheaply by the Ganges and other rivers, or over the native tracks, so metalled roads were considered to be superfluous. But Lord William Bentinck, the Governor-General of Bengal from 1828 to 1834,[1] thought otherwise, and it was he who took the first steps to build a permanent metalled road from Calcutta towards Delhi, a great highway which came to be known as the " Grand Trunk Road." His road was covered with the nodular limestone known as *kunkur*, and so he was dubbed by the facetious " William the Kunkurer." Yet the Grand Trunk Road was, and still remains, the most remarkable highway in India and one of the finest in the world, and it is only in recent years that its *kunkur* has proved unsuitable for increasing traffic.

In Provinces other than Bengal, metalled road-construction was also long delayed. For instance, Lord Elphinstone, as Governor of Madras, encountered such opposition in 1837 to his proposal to extend his roads that a certain Member of Council wrote to England that, " The silly young nobleman *actually talks of making roads !* " It is recorded also that when the Collector of a district was asked to say what roads he required he replied that he did not need any because the people used no carts. In the face of such obstruction and apathy it is not surprising that the growth of roads was slow and haphazard in its early stages. An official in Bengal, writing in 1833, says :—[2] " As to the roads, excepting those within the limits of the civil stations, 16 miles between Calcutta and Barrackpore is all that we have to boast of. In addition to this, the foundations of a road between Benares and Allahabad and of one between Jubbulpore and Mirzapur have been commenced, and an attempt is now making for another between Allahabad and Delhi ; but unless the construction of these roads be on a better plan, Government might just as well spare their money."

There is no doubt that military engineers were not attracted by road-construction on the trade routes of India. The work was dull and monotonous. The life offered few compensations for its inevitable hardships and isolation. Big rivers were not bridged ; even small rivers and streams were sometimes allowed to interrupt the line because money was scarce. There was nothing to whet the ambition of the budding engineer. He longed to leave Buildings and Roads for Irrigation, and, in later, years, Railways, or to sample the delights of Himalayan exploration in the Survey of India. Advancement in his profession could be attained only by conspicuous

[1] Lord William Bentinck was afterwards the first Governor-General of India from November, 1834, to March, 1835. He was a great social reformer and economist, but unpopular.

[2] *Notes on Indian Affairs*, by Shore, Vol. I.

work, and there is little conspicuous in driving a straight road mile after mile across a level or gently-undulating plain. This may account for the fact that, with one exception, there are few records of the early roadwork of military engineers in the plains of India. The exception is the Grand Trunk Road from Calcutta to the far north-west, which was much in the public eye after it had progressed beyond Bengal. But this was no mere trade route, though used as such. It was designed primarily as a military thoroughfare, and along it marched the armies to fight the Sikhs or invade Afghanistan. In the history of this road and its branches into the Himalayas, and of the frontier roads beyond the Indus, will be found most of the road-making exploits of military engineers in Northern India.

The Grand Trunk Road stretches in an unbroken line for more than 1,500 miles from Calcutta to Peshawar, and is prolonged to the border of Afghanistan by the route through the Khaibar Pass.[1] From Calcutta, through Burdwan, it runs straight to the southern bend of the Ganges near Benares and Mirzapur, passing through the Vindhya Hills on its way. Leaving Mirzapur, it then takes the line of the Ganges valley to Allahabad and Cawnpore; afterwards it follows the eastern bank of the Jumna to opposite Agra and Delhi, to which it is united by bridges. Northwards of Delhi, it passes through Karnal and Ambala, then swings north-westwards through Ludhiana, Jullundur and Amritsar, and westwards to Lahore; then northwards again to Wazirabad, through Jhelum and Rawalpindi, across the mighty Indus at Attock, and finally through Nowshera to Peshawar. Such is the course of the great highway which was built from end to end of Northern India by military engineers. Two names stand out in connection with it—those of Robert Napier and Alexander Taylor—but only in its later stages; its beginnings were made by other engineers, whose names are seldom recorded because of the laxity with which the records of road-construction were then kept.

It is said that between 1772 and 1785 a certain Captain Charles Rankin of the Bengal Infantry—an Engineer who is noted as "struck off" in 1793[2]—began to make a track of some sort from Calcutta towards Benares; but the line he took, and how far he progressed, are uncertain. The true beginning of the Grand Trunk Road was made by Lord William Bentinck about the year 1832, when Captain George Thomson, B.E., afterwards known as "Thomson of Ghazni" because of his exploits in the First Afghan War, was appointed to construct its first stretches. Thomson worked for five years on the Burdwan-Benares section before leaving civil employment to become Commandant of the Bengal Sappers and Miners at Delhi in March, 1837. Colonel Sir Thomas Anbury, K.C.B., the Chief Engineer at the

[1] A reference to the Sketch Map of Northern India at the end of this volume will help to explain the route.

[2] *Alphabetical List of the Officers of the Indian Army*, 1760–1834, by Dodwell and Miles, p. 216.

NEAR JAMRUD ON THE NORTH-WEST FRONTIER.

capture of Bhurtpore, wrote of Thomson in 1833 that there was not a more talented, practical or zealous officer in the Army, but that he was "overladen with an impracticable multitude of duties extending over 330 miles of road."[1] It seems that the unfortunate Thomson had many other duties besides the building of the great road and driving the huge gangs of convicts employed on it.[2] He was independent and self-reliant by nature, and being also hot-tempered he fell foul of the Bengal Military Board, a provincial body which was composed of the heads of the civil departments of the Army and controlled all roadwork until Lord Dalhousie formed the Public Works Department for that and other purposes in 1854. Thomson gave his road a width of 16 feet on a low embankment 30 feet wide, laying eight inches of *kunkur* which he rammed down to a thickness of six inches. It is curious that when the Burdwan-Benares section was reported as complete, some four years after Thomson's reversion to military duty, it was not wholly metalled. The distance metalled was then about 204 miles, and the Military Board remarked that this left 137 miles "which it is believed will not require this operation." The whole was eventually covered with *kunkur*, but the remark indicates the low standard which satisfied the Board at that time.

Supervised by many different engineers, the Grand Trunk Road crept farther and farther into the north-west during the next 14 years, and by 1855 had reached Karnal, 75 miles north of Delhi and nearly 1,000 miles from Calcutta. Its prolongation to Lahore was also in hand. Bridges were built over the smaller rivers, the largest being one with 26 arches each of 50 feet span. In Bengal these structures were mostly of stone, with piers founded on cylindrical wells, but little information is available about them. No attempt was made to bridge the great rivers; the state of development of the country did not warrant such expense. The first large river encountered before reaching Mirzapore was the Son (Sone), and there the road was carried across the wide sandy bed by a stone-paved causeway, 16 feet wide and over two miles in length, resting on a concrete foundation between two rows of piles. Similar causeways were provided to carry traffic across other large rivers. Yet in spite of such economies, the Grand Trunk Road was expensive to build and maintain. Up to the year 1848 it had cost £489,100, and a sum of £35,000 was needed annually to keep it in reasonable repair.[3] The engineers had much to learn about the peculiarities of Indian rivers. Having no reliable records of previous floods, they often underestimated their waterways with disastrous results to their bridges.

[1] *The Royal (Bengal) Engineers*, by Colonel Sir E. T. Thackeray, V.C., K.C.B., p. 59. The distance was actually 341 miles.

[2] Obituary notice of Colonel George Thomson, C.B., late B.E., in *The R.E. Journal*, Vol. 16, 1886, p. 81.

[3] *Ways and Works in India*, by G. W. MacGeorge, p. 84.

Delays were frequent through shortage of funds, transport or materials. The great road from Calcutta to the Punjab was, in fact, an experiment which succeeded only through the dogged perseverance of its builders.

Another difficulty was the lack of trained subordinates. The labourers who eventually replaced some of the convict gangs were not inclined to work too hard, for many had suffered from famine. They needed constant driving, and there were few overseers to drive them. The natural indolence of the Indian cooly has sometimes led to the inclusion of a paid *shabash-wallah* in every gang, whose sole duty has been to encourage his mates by frequent roars of "*Shabash*" (Bravo !).[1] This system is said to have had good results; but the wiles practised on trusting engineers by their apparently simple workmen are legion, and the following tale may serve to illustrate the point. A young officer was once engaged in repairing a bridge, and, as the work was urgent, he ordered his men to keep at it in reliefs day and night, and pitched a tent for himself near the bridge to ensure that there was no shirking. For two nights he listened to the coolies chanting away at their work, but was surprised to find each morning that very little progress had been made. On the third night he stole out of his tent, and this is what he saw. All the coolies were seated comfortably around a cheerful blaze, smoking their hookahs and chanting with great zeal, " Oh, brother ! Oh, brother ! Pull together ! Oh, brother ! " That is India—but perhaps not India alone.

While the Grand Trunk Road was traversing Bengal and the North-West Provinces, a young engineer who was destined to extend it through the Punjab was working on the hill-road to Darjeeling. This was Lieutenant Robert Napier, of the Bengal Engineers (afterwards Field-Marshal Lord Napier of Magdala), who had been engaged on the Eastern Jumna Canal Works from 1828 to 1837. Returning from furlough in 1838, he was appointed Executive Engineer at Darjeeling to replace Lieutenant John Gilmore, of the same Corps, who had been sent there to open a settlement[2] and raise two companies of " Sibandi Sappers."[3] Gilmore had managed to enlist about half of each company, and had obtained some Indian officers and other ranks from the Bengal Sappers and Miners; but when the rains came on earlier than usual, a few of the " Sibandis " deserted, some of the coolies died, the remainder fled, and Gilmore fell ill. " I was

[1] Major-General Sir Sydney Crookshank states that a *tom-tom-wallah* was a prominent feature of the gang organization during his roadwork in the Chitral Expedition of 1895, and could incite the coolies to frenzied labour.

[2] The first European to visit the site was Colonel G. W. A. Lloyd (Political Department) in February, 1829, and he advised that a sanatorium should be established there. Major J. D. Herbert, Deputy Surveyor-General, and Mr. J. W. Grant, Resident at Malda, then surveyed the Sikkim Hills and supported the recommendation. Darjeeling was ceded to the British by the Raja of Sikkim early in 1838.

[3] An armed corps, formed temporarily to furnish labourers accustomed to work in the mountains. (See Chapter XXII, Vol. I.)

suddenly ordered from the extreme border of Nepaul," writes Napier,[1] "to relieve Gilmore for one month. I arrived somehow. Just then our relations with Nepaul became strained, and it was thought desirable to complete the Sebundy Sappers with men from the border hills unconnected with Nepaul. When they arrived I found, instead of the 'fair recruits' announced, a number of most unfit men. I was much embarrassed as to what to do with them, but night was coming on so I encamped them on the newly-opened road, the only clear space amidst the dense jungle on either side. During the night there was a storm—and in the morning, to my intense relief, they had all disappeared! In the expressive words of my sergeant, there was not a 'visage' of the men left. I eventually completed the Sebundy Corps with Nepaulese. My month's acting appointment, however, was turned into *four years*."

In 1841 Napier was transferred from Darjeeling to Karnal, a large military station north of Delhi; but this place was so unhealthy that it was decided that all troops should be removed from it, and in 1844 he was sent to Ambala, 50 miles farther north, to build a new cantonment. The Sikhs of the Punjab were restive, and Lord Ellenborough, the Governor-General, wished to concentrate his available strength nearer to the Sutlej frontier. The work at Ambala was progressing rapidly under Napier's energetic direction when he was called away in 1845 to join the Army of the Sutlej in the First Sikh War. Returning to Ambala in the following year, he chose the site for the hill-station of Dagshai and finished the laying-out, and most of the building, of Ambala Cantonment before he was summoned to the siege of Multan, which ushered in the Second Sikh War. The Battle of Gujarat having been fought and won on February 16th, 1849, Napier was then appointed "Consulting Engineer to the Resident and Council of Regency in the Punjab," but was glad, no doubt, to exchange this cumbersome title for that of "Civil Engineer of the Punjab" when that Province was annexed. A stupendous task awaited him: the transformation of a war-ravaged wilderness into a fruitful and orderly addition to our Indian Empire. He was required to build cantonments, forts, civil offices, bungalows, roads, bridges and canals, and, as a start, he pushed forward the preparation of the Bari Doab Canal project by Lieutenants J. H. Dyas and Crofton of his Corps. But he felt that the most urgent need was for good bridged roads, and so he came into touch with the Grand Trunk Road, which he extended rapidly through the Punjab.

It should not be imagined that the Grand Trunk Road was the only important communication under construction in Northern India during the Afghan and Sikh Wars. Work was in progress in many districts. For instance, 400 miles of embanked roadway and

[1] Letter from Field-Marshal Lord Napier of Magdala, G.C.B., G.C.S.I., to Colonel Sir Henry Yule, K.C.S.I., C.B., quoted in a letter by Sir Henry Yule, dated February 21st, 1885, which appears in *The R.E. Journal*, Vol. 15, 1885, p. 64.

77 bridges were made in Bareilly District between 1839 and 1844, and in 1840 work was begun at Agra on a great trunk line to extend for 735 miles to Bombay. Colonel H. E. S. Abbott, C.B.E., D.S.O., late R.E., writes :—[1]" In 1849 my mother and four children travelled about 450 miles by bullock cart from Mhow to Bombay. My father had a huge van made in his compound—a *wagon-lit* with wonderful fittings. Into this my mother and family were packed. The roof groaned under the weight of servants and luggage. How many pairs of bullocks were used, or the time taken, I do not know, but the journey was accomplished without mishap, stage by stage, with my father riding alongside—and shooting—as they went along. So to Bombay, where my mother and the children embarked for Suez in the P. & O. s.s. *Himalaya,* a sailing ship with auxiliary steam propellor. From Suez they went overland to Alexandria, and then by ship to England. Apparently the trunk road to Bombay from Agra had not been completed in 1849, or at least the *dak-gharry* service had not been established."

In the Azimgarh District, 638 miles of embanked and partially bridged road were finished by the year 1851 ; and before the Indian Mutiny the bridging and metalling of a " Great Deccan Road " had been started from Mirzapur, on the Grand Trunk Road, towards Nagpur. " By the year 1870," says MacGeorge,[2] " nearly all the undertakings connected with the earlier through trunk routes had been completed, including many of the fine engineering works leading to the Himalayan hill-stations or to communicate with the Tibetan trade routes beyond them." Most of this was accomplished after the conduct of affairs had been transferred from the East India Company to the Crown. Writing of earlier days, Chesney remarks :—" The Court of Directors did not recognize the prosecution of public works as a necessary part of their policy. The construction of a road or canal was regarded by them much in the same light that a war would be—as a necessary evil, to be undertaken only when it could not be postponed any longer, and not, if possible, to be repeated." It was stated in 1858 that a single English county had more good roads than the whole of India, and that Manchester alone had spent on its water-supply more money than the East India Company had expended in 14 years in public works throughout India. In justice, however, to the Company in its last years, and particularly during the administration of Lord Dalhousie, it should be stated that matters then showed rapid improvement. Great progress in road- and bridge-construction was made in the Punjab under the administration of the two Lawrences, and also in the North-West Provinces between 1843 and 1857 under the rule of those able Lieutenant-Governors, James Thomason and John Colvin.

[1] Extract from a letter from Colonel Abbott to the author, dated July 13th, 1933.
[2] *Ways and Works in India,* by G. W. MacGeorge, p. 85.

In 1850 the first horse-drawn mailcarts began to run on the Grand Trunk Road between Calcutta and Delhi. Travellers could then move in far greater comfort than before. Lord Lawrence used to say that in 1830, when he was a young man, he was thought to have performed an extraordinary feat because, travelling day and night, he reached Delhi a fortnight after leaving Calcutta.[1] Those were the days of the "*palkee gharry*," which General Sir Bindon Blood describes as a palanquin which could be placed on a wheeled platform when wheeled transit was possible and carried by men when it was not. Sir Bindon never saw this weird contrivance, but he heard tales of it after his arrival in India in 1861. The *dak gharry* of his time had just sufficient lying-down accommodation for two people, using their own bedding. Then, as now, the Englishman east of Suez was never separated from his blankets whatever else he might lose. "I have often been asked how one travels in India," said Medley in 1872.[2] "Well, where there are no railways and you have a good metalled road, you travel by *horse-dak* as it is termed, that is, you hire a carriage, which is a four-wheeled cab slightly altered, and engage relays of horses at every five or six miles, and by travelling all night to escape the heat, you manage to accomplish 60 or 70 miles between dinner and breakfast pretty comfortably at a cost of about a shilling a mile. The horses are an abominable set of brutes, and generally begin by obstinately refusing to stir a step, or perhaps lying down in the shafts. Then the native horseman, after patiently undoing the rotten harness and getting the animal once more on his legs, addresses him by all manner of endearing epithets. 'Go on, my brother.' (Horse doesn't move.) 'Go on, my son, my brave, my hero.' (No result.) A cut with the whip, followed by a vicious kick from the horse. Coachee changes his language. '*Go on, you scoundrel, you villain.*' A shower of blows, a volley of abuse from the passenger inside, more kicks and plunges from the horse, and finally, by the aid of the whole stable establishment, who push behind, whack the horse, and yell like fiends, off you go at ten miles an hour. If there is no road you must be content with the old-fashioned palanquin or doolie, a species of coffin with doors at the sides. When I first landed in India (in 1849) I travelled from Calcutta to Allahabad, a distance of 500 miles, in this way, and took 12 days on the road."

The first great impetus to road-making in India was given on the annexation of the Punjab, and the man who gave it was Colonel Robert Napier, late of the Bengal Engineers. In the words of Bosworth-Smith,[3] "If a thing was to be well done, and without a too close calculation of cost, Napier was the man to do it." He was

[1] *India. Its Administration and Progress*, by Sir John Strachey, G.C.S.I., p. 232.

[2] Lecture delivered at Chatham by Lieut.-Colonel J. G. Medley, R.E., in July, 1872, quoted in his *India and Indian Engineering*, pp. 32–34.

[3] *Life of Lord Lawrence*, by R. Bosworth-Smith, Vol. I, p. 304.

allowed to choose his subordinates, and his first choice fell on Lieutenant Alexander Taylor, B.E., the young subaltern who had brought him and the siege train safely down the Sutlej to the siege of Multan. It was a bold selection, for Taylor was only 24 years of age and had had no experience of road-making. Napier proposed to place him in sole charge of the extension of the Grand Trunk Road from Lahore to Peshawar, a distance of some 278 miles. The road was intended primarily for military traffic, and accordingly required careful alignment, easy gradients, strong bridges and suitable camping-grounds at intervals. Labour was scarce, as the canal works had attracted the bulk of the workers. Yet an army of road coolies—amounting at one time to 60,000 men—was collected gradually from among the low-caste (Mazbi) Sikhs, and some of these men were afterwards most useful as "Punjab Sappers" or Pioneers at the siege of Delhi.[1] Hillmen were recruited also, but the trans-frontier Pathans would not consent to join.

Alexander Taylor was one of the most remarkable men who have ever set foot in India. His exploits in the Siege of Delhi have been told already. It remains only to describe some of his achievements, and those of his subordinates, before they were called away to that tragic and heroic episode. Straight as a die, scorning mediocrity, seething with energy which had to find immediate expression in action, self-confident, imperious, outspoken, and, like John Nicholson, a born leader of men, Taylor was admired by many, loved by some, and disliked by not a few. He was a mere boy when he shouldered the huge responsibility of building the Grand Trunk Road under the direction of Robert Napier, and, like many another Irishman, he remained a boy for the greater part of his life. His daughter, Miss Alicia Taylor, writing of the feats with which he used to entertain his companions, says that he could stand on his head in the middle of a mess-table covered with glass, silver and fruit without displacing or breaking anything;[2] also that he once jumped a dinner-table with a leaf on edge placed across its centre, and on another occasion, 12 mess-chairs in single file. For another exhibition he would have 12 solidly-made chairs put in a row at small intervals. Dashing at the first, he would run swiftly along and over the whole line, stepping on their backs only. Cat-like he skimmed from end to end, each chair falling as he left it. He could run up a wall, over a picture hung not too high, and off again, the speed with which he rushed at the vertical face keeping him against it long enough to perform the trick. He supplemented these feats of agility by others of extraordinary daring. Once, for instance, he swam the roaring torrent of the Indus at Attock, a feat which no white man had ever attempted. From observations of the movements of logs

[1] See Vol. I, Chapter XVII.
[2] *General Sir Alex Taylor, G.C.B., R.E.*, by A. C. Taylor, Vol. I, p. 136.

which he threw into the river, he was satisfied that if he remained perfectly still in the whirlpools he would be thrown clear of them in time as the logs were ; so one day he was rowed to the starting-point with his friend Leonard Bean—one of the three brothers known respectively as " Broad Bean " (the sturdy Leonard), " French Bean " (the suave John) and " Has Been " (Charles with an inferiority complex)—and dived into the maelstrom. Breathless and battered he survived the ordeal, swam through the racing flood below the whirlpools, and reached the farther bank, a feat which was the talk of the Attock boatmen for more than a generation. A first-class footballer and wrestler, a keen shot and fisherman, a capable engineer, and what would now be termed " a live wire "—such was Alex Taylor.

Several Bengal Engineers served under Taylor on the Grand Trunk Road, among them being Lieutenants J. G. Medley and J. St. J. Hovenden, and together they extended the wide highway steadily northwards from Lahore through Wazirabad and Jhelum. So well did the communications of the Punjab as a whole progress under the supervision of Napier that, within three years of the annexation, 1,349 miles of main road had been built, 2,487 miles traced and 5,272 miles surveyed. In addition, 550 bridges were erected and hundreds of miles of minor roads completed. The engineers had no machinery or plant, and no article ordered from England could be expected to arrive in less than ten months. As regards the Grand Trunk Road, the country to be traversed was easy enough as far as the River Jhelum, but then it changed to a rugged tableland intersected by deep and precipitous ravines which presented most difficult problems of grading, alignment and bridging. Accordingly, as the work was urgent and economy the order of the day, the road was often carried through the beds of *nullahs* on stone causeways called " Irish bridges " because Taylor was an Irishman. But the general development of the Punjab communications was interrupted in 1857 by the Indian Mutiny, and it could not be resumed seriously until the end of the following year, when the last embers of the great revolt had been extinguished in Northern India.

Before the outbreak of the Mutiny, Colonel Robert Napier had left the Punjab ; and even whilst he was the senior Engineer in charge of all civil works, he was called away to a Black Mountain expedition in December, 1849, and to another against the Jowaki Afridis in November, 1850. When he returned to the Punjab in 1851, John Lawrence alone ruled that Province,[1] and Napier's designation was changed from " Civil Engineer " to that of " Chief Engineer." Lawrence soon became uneasy about the expenditure on civil works. His Chief Engineer saw what the country needed

[1] Previously it had been ruled by a " Triumvirate " of the two Lawrences and Robert Montgomery.

and determined that it should have it without too nice a regard for expense ; but Lawrence, though pleased with the results, complained at last to the Governor-General and wrote severely to Napier.[1] The breach between the two men then widened rapidly, and in 1856 Napier went on furlough to England and severed his connection with the Punjab. He returned to India in time to join in the reinforcement of the Lucknow garrison by Havelock and Outram. Meanwhile the appointment of Chief Engineer in the Punjab was held by Lieut.-Colonel E. L. Ommaney, B.E. Napier's expenditure on communications may have seemed prodigal, but it was justified by subsequent events, for along his roads marched the reinforcements and artillery which did so much to help in the recapture of Delhi from the mutineers.

And so we come to the time when young " Buster " Browne, a subaltern of the Bengal Engineers, made his first appearance on the Grand Trunk Road. James Browne landed in India in December, 1859, and, after serving under General Chamberlain against the Mahsud Waziris, was placed in charge of the final or " Indus " section[2] of the great highway in June, 1860, and worked on it for more than two years under Alexander Taylor. Browne was a man after Taylor's own heart, and a warm friendship sprang up between the two. He came to understand the Pathans as few men have done, and was the first officer in the Indian Army to qualify in their language. His happy-go-lucky, jovial nature appealed to the tribesmen as much as his reckless daring, and he was ever ready to turn his hand to any job. Once when, clad in a pair of bathing-drawers, he was labouring with his men in the bed of a river, a lady happened to pass along the bank. " Oh, look at that man down there," she exclaimed. " He is so fair that you could hardly suppose him to be a native." " Well," said her companion, " he may *look* white enough, but he is really Browne." There is another story that, when " Buster " wanted to use some native boats for a bridge, he covered sheets of paper with calculations to find their displacement and was much disgusted when his humble *mistry* told him that his results were wrong. The man then explained that, on his own initiative, he had ordered some coolies to fill one of the boats with stones until it sank to the safe load-line, and afterwards, by weighing the stones, he had got the correct answer.

The first important task which fell to Browne was to help for a few months in digging a drift[3] under the bed of the River Indus at Attock preparatory to the construction of a tunnel for the Grand Trunk Road. " The Indus at Attock," writes Miss A. C. Taylor,[4]

[1] Obituary notice of Field-Marshal Lord Napier of Magdala, G.C.B., G.C.S.I., appearing in *The R.E. Journal*, Vol. 20, 1890, p. 62.
[2] The section between Attock and Peshawar.
[3] *Drift.* A small exploratory gallery driven in advance of a tunnel.
[4] *Life of General Sir Alex Taylor, G.C.B., R.E.*, by A. C. Taylor, Vol. I, p. 123.

"provided the Engineers with the most difficult of the problems which they were set to solve, viz., the substitution of a permanent way for the ferry and boat-bridge which since time immemorial had spanned one of the most historic river-reaches of the world; a comparatively narrow neck of water across which India's northern invaders—Alexander the Great, Tamerlane, Babar, Nadir Shah, Ahmad Shah the Abdali—had marched from the mountain gorges of Afghanistan into India." The Fort at Attock lies on the left or eastern bank of the Indus below the influx of the Kabul River, and the mighty gorge contracts gradually as it nears the Fort, forming a sort of funnel with the Fort at its neck. It was at this point that a ferry for the Grand Trunk Road was worked, supplementing a temporary bridge of boats established, at suitable seasons, above the Fort. While in flood, the Indus flows past the Fort with a surface velocity of from nine to fifteen miles an hour, and thus the passage by water is always difficult and sometimes impossible. Many bridging schemes were considered, but all were rejected. Yet the maintenance of a permanent crossing was essential for the supply of the force of 8,000 men in the Peshawar Valley, and of the Kohat and Bannu garrisons.

As far back as 1853, Lieutenant (afterwards Lieut.-General) W. A. Crommelin, B.E., had submitted designs for suspension bridges at Attock, and a tubular structure had also been considered. Taylor wished to build a suspension bridge, but all ideas of bridging were abandoned when Lieut.-Colonel Alaric Robertson, of the Madras Infantry, submitted a scheme for a tunnel while Taylor was on furlough in 1859.[1] Robertson's tunnel was to be 24 feet wide and 20 feet high, with a total length of 7,215 feet, and it was to burrow under the Indus near Attock Fort where the width of the river was 1,215 feet. According to this scheme the foundation level of the roadway under the Indus would be 82 feet below the low water-level of the river. The descending and ascending sections would each be ventilated by five shafts, and the whole tunnel would be lit by gas. Adequate drainage was to be secured by giving the lowest portion a gentle slope towards the Attock side, and by pumping. It was a daring scheme, and the Government was bold enough to put it in hand at once. The sinking of the shafts nearest to the river began on March 12th, 1860, and when they had reached the proper depths —168 feet on the Attock side and 93 feet on the other—an exploratory drift, about six feet by three feet in size, was begun under the river from the bottom of each shaft.

It is curious that this ambitious undertaking was neither projected nor put in hand by Bengal Engineers, but by infantry officers. The hard work of excavating the shafts and drifts was done by Mazbi

[1] Article entitled "The Indus Tunnel," by Lieut.-Colonel Alaric Robertson, appearing in *Professional Papers on Indian Engineering*, Vol. II, 1865, No. LV, p. 34. (Robertson was a Superintending Engineer, P.W.D.)

Sikhs of the 24th Punjab Infantry under Lieutenant John Chalmers[1] of that regiment, assisted by six British miners from H.M. 94th Regiment; and in April, 1861, when Robertson was in England, another infantry officer, Captain Sandilands, directed the operations.[2] Great difficulties were encountered soon after the start. The Indus at Attock sometimes rises as much as 100 feet when in flood, and this occurred in June, 1860. Such copious leakage then developed through the upper layers of rock at the western shaft that work had to cease there for several months. Another stoppage of work in that shaft occurred in May, 1861, and lasted until November, and there was a fall of rock in the drift. In the summer of 1862, a pump installed in the western shaft broke down, and as nearly £6,000 had then been spent on the drifts and shafts, Government called a halt. Finally, when only 258 feet of the drift remained to be dug to complete a preliminary way under the river, the whole scheme was abandoned in November, 1864. It needed only the subsequent failure of an attempt to establish a flying bridge to prove that nothing short of a permanent steel bridge would meet the situation, and so, after the railway had reached Attock in 1880, a bridge of five girder spans was erected by Sir Francis O'Callaghan and Mr. Johnson to carry the railway on its upper, and the road on its lower, members. This bridge was opened on May 24th, 1883, by which time the railway had been carried to Peshawar. The Attock Tunnel scheme of 1860-64, though it ended in disappointment and loss, taught our military engineers many valuable lessons.

On the Jhelum-Attock section of the Grand Trunk Road the largest bridge was that at Sohan, described as "a grand monument to its designer, Colonel Alex Taylor," and consisting of 15 masonry arches each of 63 feet span. Many of the smaller structures, however, were of timber (deodar) brought from the hills. In the section between Attock and Peshawar, "Buster" Browne was put in charge of the construction of an important bridge across the Bara River, seven miles east of Peshawar. A "strut and strain" timber bridge, resting on piles and wooden piers, had been proposed, but the great flood in June and July, 1861, caused Taylor to adopt another design. During that flood the river at Bara rose 18 feet in five minutes, the first wave coming down in a roaring wall of water which washed everything away, including the only pile-driver in India. The new design was for a bridge of three spans (53, 74 and 53 feet) resting on brick piers founded on wells, the roadway being hung by iron ties from wooden bowstring girders formed by planks clamped together. When the rains were over, Browne began the building of this structure and pushed it on at a great pace. His peculiar, but remarkably effect-

[1] Chalmers was one of Taylor's Assistant-Engineers on the Grand Trunk Road.
[2] Second article entitled "The Indus Tunnel," appearing in *Professional Papers on Indian Engineering*, Vol. II, 1865, No. LXI, p. 124.

ive, methods are described as follows by Taylor :—[1] "In the mud, two open excavations for the piers were in hand, and everyone was very busy. Near one of the excavations, seated on the top of a not very dry mound of earth, was Browne, his shirtsleeves rolled up and his shirt front open. On the same mound, but on a lower level and somewhat to his left, was a cashier with a supply of small coin. In a similar position, somewhat to his right, was a sweetmeat man, while between them were musicians of the country playing spirit-stirring airs. The procedure was this. The mud-drenched cooly came up the slope from the excavation with a basket-full of mud on his head. Having emptied the basket, he walked to the cashier and received a coin. He then moved to the sweetmeats, and receiving one, put it in his mouth while the stirring sounds of the musicians helped to circulate his blood. Browne, from his mound, encouraged the workmen below by gestures and by words when a pause occurred in the music, and the bridge was completed in very satisfactory time." Another large wooden bridge was erected by Taylor and Browne in 1862-63 across the Haro (Hurroo) River, some 33 miles north-west of Rawalpindi, consisting of ten spans of 40 feet trusses. This bridge was carried away by a flood in 1895. A temporary wooden bridge was built on the same site in 1918, but it was not till 1925–26 that Lieut.-Colonel A. S. Holme, R.E., replaced the temporary bridge by a modern steel-girder structure. All the wooden bridges built by Taylor and Browne on the Grand Trunk Road, including the Bara Bridge, have now been replaced by modern types ; but they served their purpose, which was to open up traffic quickly and cheaply when money was scarce and steel-work unobtainable.

From bridging on the almost completed Grand Trunk Road, Browne joined the Ambela Expedition in 1863[2] and fought in every battle. Afterwards he went as an Executive Engineer to the Kohat division, extending to the border of the Sind, the Peshawar and Hazara districts being soon added to his charge. He was handicapped by the loss of the sight of his right eye through using a theodolite in too strong a light, but this did not affect his energy. In his new charge he erected numbers of civil buildings, barracks, forts and river-training works, and then, after a period at Roorkee, he was sent in 1865 to make the Kangra Valley Road from Pathankot to Palampur (the centre of the tea-growing industry) with a branch to Dharmsala, a mountain village about 80 miles north-west of Simla. This road was designed to encourage trade and help the tea estates, and it followed the general run of the Siwalik Hills for 120 miles along a most difficult line. Men had often to be lowered from the tops of precipices to make the holes for blasting charges. Of the numerous bridges which Browne constructed on the Kangra Valley

[1] Letter from Colonel Taylor quoted in *The Life and Times of General Sir James Browne, K.C.S.I., C.B.*, by Lieut.-General McLeod Innes, V.C., R.E., p. 54.

[2] See Vol. I, Chapter XXI.

Road there were two remarkable ones made of brickwork, each of single spans of 140 feet, which were said at that time to be the largest in the world outside America. These were the Nigal and Buner Bridges. The Nigal Bridge survived the great Dharmsala earthquake of 1905, but the Buner Bridge collapsed, and was replaced, first by a suspension bridge made by a company of Bengal Sappers and Miners under Lieutenant M. R. Elles, R.E., and afterwards by a steel-girder bridge. The Nigal Bridge stands to this day as a testimony to the soundness of Browne's work.

Other large bridges were erected by Browne on the Kangra Valley Road, notably a timber structure, 214 feet in length, at Dehri, and a concrete bridge of 48-feet span at Daron, and before he left the district in 1868 his reputation as a builder of bridges was firmly established. So we find him placed on special duty in 1873 to design iron bridges not only for his own Province, the Punjab, but also for the North-West Provinces. Some of these designs were for bridges approaching 300 feet in span. For a suspension bridge constructed across the Jumna at Kalsi on the road to Chakrata—the largest at that time in India, with a central span of 260 feet and two others of 140 feet each—Browne prepared not only the designs and estimates but also the working drawings. This bridge still stands, and is shown in the accompanying illustration. Browne provided the hill-station of Dalhousie with a water-supply system in 1874, designed a stiffened suspension railway bridge for the Indus crossing at Sukkur in the following year,[1] and in 1876 began to survey and build a railway from Sukkur to Sibi on the road to Quetta. After a period of political service in the Second Afghan War, and a few years in the Military Works Department, he emerged as the most eminent railway engineer of his time. As such, his exploits will be recorded later. For the present it is necessary to say good-bye to a truly remarkable character, who did almost as much for the Punjab as Napier and Taylor had done.

While the plains between Delhi and Peshawar were being traversed by excellent roads, similar, if less ambitious, work was in progress in other parts of North-Western India. Even the remote Derajat district, the long and narrow strip of country between the Indus and the Sulaiman Mountains, was not altogether neglected, and there was considerable activity in Sind and towards Quetta. For some years after its occupation by the British in 1849, the Derajat was almost unknown. No British soldiers were stationed there: no British women were allowed to go there: not a mile of road, nor a wheeled vehicle, could be found there. Such traffic as existed was by camel caravans, or in boats along dilapidated irrigation channels. The land was sparsely populated, and alternately parched by heat and deluged with rain. It was, in fact, a howling and uncharted

[1] This design, however, was not carried into execution.

KALSI SUSPENSION BRIDGE, CHAKRATA ROAD.

Constructed by Captain James Browne, Royal (late Bengal) Engineers.

wilderness. The first thing to be done was to survey the country and prepare a rough map of it, and this was completed early in 1854. No money was available for embanked and properly metalled roads, but a main road of some sort was laid out roughly parallel to the line of the Indus and to that of an existing frontier road near the hills, and so arranged that it passed through the principal trading centres. This route was then connected to the frontier road by cross-roads at intervals, and by 1870 the Derajat had a fairly good system of communications.[1]

Metalled roads were provided in time to most of the hill-stations which fringe the northern provinces, and a few, such as the Kalka-Simla Road, were prolonged beyond them. The Kalka-Simla section of the great project known as the Hindustan-Tibet Road was begun in 1850, and in December of that year, two infantry officers, Colonel Kennedy and Major Briggs, reconnoitred the hills between Simla and Tibet for a possible extension. They found a suitable line towards Serahan, 118 miles from Simla, and during the winter of 1851–52, the Mashobra tunnel (560 feet in length) was bored through solid rock, under the direction of Briggs, at a spot some 2½ miles north of Simla.[2] By September, 1854, 80 miles of road towards Serahan had been completed and the remainder was in hand; and when the work was interrupted by the Indian Mutiny in 1857, the road had almost reached Serahan. The route adopted by Briggs, however, did not touch Rampur, the capital of Bashahr, so another infantry officer, Major Nightingale, was appointed in 1861 to make a "Sutlej Valley Road" through Rampur to join the Hindustan-Tibet Road at Serahan. In the following year, Nightingale was succeeded by 2nd Captain A. M. Lang, B.E., who opened 57 miles of road as far as Pangi, 157 miles from Simla, during 1863 and 1864, but he was then transferred to Oudh and Mr. A. Gregeen took charge of the remaining work.[3] The total length of road constructed from Kalka by Simla to Serahan was about 300 miles, and the chief credit for this achievement should rest with Lang, who carried out the most difficult portions of the undertaking. In many of its sections, the Hindustan-Tibet Road was, and still remains, a remarkable piece of engineering, passing as it does through forests, across precipitous chasms, along the faces of cliffs and through many tunnels. Probably no road in the world offers such fine scenery to the traveller.

Other interesting hill-roads in the Himalayas are those leading to Naini Tal, Ranikhet, Almora and Chakrata in the United Provinces,

[1] Article entitled "Engineering in the Derajat," by Major J. G. Medley, R.E., appearing in *Professional Papers on Indian Engineering*, Vol. III, 1866, No. CXVII, pp. 278–282. The road was prolonged through Shikarpur, Larkana and Sahwan to Kotzi and Karachi, and the route from Larkana through Jacobabad, Lahri, and Sibi to Quetta was greatly improved.

[2] It was in this tunnel that Lord Kitchener broke his leg in 1904. The tunnel was then widened and lined by Lieut. A. S. Holme, R.E.

[3] Article entitled "The Hindostan and Thibet Road," appearing in *Professional Papers on Indian Engineering*, Vol. IV, 1867, pp. 373–398.

and to Dalhousie and Murree in the Punjab. The Chakrata Road, which was constructed after the Hindustan-Tibet Road, was designed by Captain F. W. Peile, B.E., and much of the surveying work was done by Captain J. C. Ross, B.E., and Lieutenant W. G. Ross, R.E.; its Kalsi bridge, as already mentioned, was designed by "Buster" Browne. The Rawalpindi-Murree Road, with its extension through Kohala to Srinagar, 200 miles from Rawalpindi, is perhaps as well known as any highway in India. Thousands of keen *shikaris*, and tens of thousands of tourists, have whirled along it to sample the delights of Kashmir. It is believed that, as far as the neighbourhood of Murree, the road was made by military engineers at some period between 1851 and 1864, for a large bridge at Salgram, half-way between Rawalpindi and Murree, was erected by Lieutenant T. G. Glover, B.E., in 1855. Colonel F. C. Molesworth, late R.E., says,[1] "We occupied Rawalpindi as a garrison after the Second Sikh War, and the oldest military buildings date from 1851. A map of Rawalpindi, dated 1865, shows that the southern part of the Murree Road was then much as it is to-day. Local report says that for many years the road went no farther than Ghora Gali, 29 miles from Rawalpindi, after which there was a bridle track." In 1865, however, mail carts were running regularly as far as the Brewery, 33 miles from Rawalpindi, and in the following year to Sunnybank, close below Murree.[2] The road had a width of 20 feet and, except in a few places, a limiting gradient of about 1 in 20. By 1890, a cart-road had been completed from Murree down to Kohala, where it crossed the Jhelum by a suspension bridge, and it was being prolonged by Kashmir State Engineers towards Srinagar.[3] The suspension bridge at Kohala was washed away in 1895, when another was built by Bengal Sappers and Miners under Major F. J. Aylmer, V.C., R.E.; this was replaced by the present girder bridge in more recent times. A road, called the Hazara Trunk Road, was made during the 'eighties from Hasan Abdul in the Attock District through Haripur to Abbottabad, and so to the Kashmir boundary near Garhi Habibulla; and in the early 'nineties a pack-road was made up the Kaghan Valley as far as the Babusar Pass on the Chilas border.

Few Royal Engineers have had so much experience of road-construction on the North-West Frontier as Colonel H. E. S. Abbott, C.B.E., D.S.O., who went to India in 1877 and was employed in the Public Works Department as early as 1878. He records that, during one week of the hot weather of 1879, there were only four white men besides himself in Dera Ghazi Khan, and that, by a very curious

[1] Letter from Colonel Molesworth to the author, dated March 31st, 1933.

[2] Article entitled "The Rawalpindi and Murree Hill Road," by Major H. Rose, Ex-Engineer, appearing in *Professional Papers on Indian Engineering*, Vol. II, 1865, No. LXII, p. 128.

[3] It is probable that Major-General R. de Bourbel (late B.E.) had some part in the final stages of this work, as he was Chief Engineer to the Kashmir Durbar about 1897.

coincidence, their names were Friar, Deane, Bishop and Pope! In the second phase of the Second Afghan War, Abbott was in charge of the construction of the Khaibar Road from Ali Masjid, through Landi Kotal, to Landi Khana. Afterwards, he made and improved roads in the Mahsud-Waziri country and beyond Kohat. In 1882 he had charge of the Kohat–Kushalgarh road to the Indus boat-bridge at the latter place, which was the terminus of the railway from Rawalpindi. At that time the Indus was a formidable obstacle in the line of communication towards Afghanistan, for the boat-bridge had often to be dismantled hastily on receipt of telegraphic warning from Attock of an approaching flood. "I was just going on leave at the end of June," writes Abbott,[1] "when we were caught unprepared. No warning came from Attock, and the river rose 40 feet in the night before the boatmen could dismantle the bridge. It became a raging torrent, bringing down *débris* of all sorts. Huge logs soon wrecked the centre boat, and the adjoining boats and superstructure began to go. But two or three intrepid boatmen went some way upstream, and launching themselves into the torrent on inflated bullock skins, reached the middle of the suspended cable which held the boats. They cut it in half an hour, and away went the two halves of the bridge, wheeling round the shore ends into comparatively slack water. Only two boats broke away, and these, and most of the superstructure, were recovered later." Abbott's later work included the construction in 1895 of most of the Malakand Road between Dargai and Chakdarra, a feat which has been mentioned already in Chapter XXI, Volume I.[2] His work on this road was continued by Captain H. C. Nanton, R.E., and part of the route is still shown on some maps as "Abbott Road."

It is impossible to describe in a few pages all the communications which have been established along the North-West Frontier during the last 40 years. A few remarks on these must suffice. About the year 1890, the "North-West Frontier Road" was constructed from Kushalgarh through Kohat and Bannu to Dera Ismail Khan, and another road was made from Dera Ismail Khan to Tank. Multan had already been connected to Dera Ghazi Khan, and this road was then continued through Baluch territory by Lieut.-Colonel E. Harvey R.E., with a staff of assistants among whom were Lieutenants R. S. Maclagan, H. C. I. Birdwood and A. B. Rouch, R.E.[3] It is an important line of communication and is about 227 miles in length. The section between Rakhni and Sakhi Sarwar (near Dera Ghazi Khan) presented formidable engineering obstacles, and many

[1] Extract from notes given to the author by Colonel H. E. S. Abbott, C.B.E., D.S.O., on June 12th, 1933.

[2] The officer in immediate charge of the greater part of the work was Lieut. S. D'A. Crookshank, R.E., working with the 32nd Sikh Pioneers and large gangs of Swati coolies.

[3] *Civil and Military Gazette, India.* Issue dated December 4th, 1888. (See *The R.E. Journal*, Vol. 19, 1889, p. 39.)

hardships were experienced by the engineers and their men in carrying the road through Loralai across the lofty plateau between Rakhni and Harnai towards Quetta. The rising of the frontier tribes in 1897 was the signal for considerable activity in road-construction in Waziristan. A road was begun from Bannu up the Tochi Valley through Miramshah to Datta Khel, and was finished in 1898. The opening up of Waziristan by the modern Circular Road and its extensions, has been described already in Volume I; such military roads, constructed after the Great War, hardly come within the scope of this sketch of the civil work of military engineers.[1]

Soon after the Indian Mutiny a policy was initiated by which the upkeep of certain roads devolved upon municipalities. These bodies became responsible for the roads within their jurisdiction. The formation, in later years, of District Boards to improve local communications furthered a process of decentralization which reduced the responsibilities of the Public Works Department. The number of Royal Engineers in the Buildings and Roads Branch then began to decline, and only one officer of the Corps is now serving in that Branch except on the frontier. In 1897, however, there was a fairly large sprinkling of Royal Engineers in Buildings and Roads employment in the Punjab. All military works in the frontier and trans-frontier stations were then carried out by the Public Works Department, except in Peshawar itself. Up to 1899, with one exception, every Chief Engineer of the Punjab Buildings and Roads Branch was a Royal Engineer, the exception being Mr. E. E. Oliver, who is supposed to have been the original "Potiphar Gubbins" of Kipling's *Departmental Ditties*. Owing to famines in 1897 and 1900, and an earthquake disaster at Dharmsala in 1905, little money was available for roads in the Punjab during the opening years of the present century; and when the North-West Frontier Province came into existence in November, 1901, the activities of the Public Works Department were curtailed by the transfer of all roads and buildings in the five frontier districts of Hazara, Peshawar, Kohat, Bannu and Dera Ismail Khan to the Military Works Services. In general it may be said of the Punjab and North-West Frontier Province that in the early years of the present century little was done to improve the road communications except in the hills. Most of the available

[1] It may not be out of place, however, to mention a remarkable feat of military road-making accomplished during the N.W. Frontier disturbances of 1933 (since the completion of Vol. I) in the Lower Mohmand country, north of Peshawar. In 29 days a metalled road, 20 miles long, for two-way motor traffic, was built between Pir Kala, near Shabkadr, and Yusuf Khel, six miles north of Ghalanai; and in a further 26 days its 130 bridges and culverts were finished. High speed in construction was achieved through experience, efficient organization, and modern machinery. Much blasting was necessary in one mountain section from Dand to Karapa. The alignment of an old Buddhist road was followed for some distance. Two companies of Bengal Sappers and Miners, and large gangs of tribal labourers under contractors, carried out the work, which was controlled by the C.R.E. Peshawar District and directed by a staff of Field and Assistant Field Engineers, R.E. Safety was ensured by armed guards of local tribesmen.

money was allotted to canals and railways. The Grand Trunk Road was kept in good order on purely sentimental grounds: the other roads had to take their chance unless they acted as feeders for railways. The position was more favourable in the United Provinces and Bengal, where the natural resources of the country had been more fully developed and money was more plentiful.

The names of many Bengal and Royal Engineers figure in the history of the northern roads and buildings of India, and among them those of Field-Marshal Lord Napier of Magdala, the first Chief Engineer in the Punjab; Major-General E. L. Ommaney, who succeeded him; Major-General R. Maclagan; General Sir Alexander Taylor, of the Grand Trunk Road; Major-General Sir James ("Buster") Browne, Lieut.-General C. Pollard, Major-General D. Limond, General Sir Æneas Perkins, Colonel J. P. Steel, Major-General G. F. L. Marshall and Colonel S. L. Jacob. All of these officers were Chief Engineers in the Punjab during the last century. Among the Punjab Buildings and Roads engineers of the present century may be mentioned Colonels H. E. S. Abbott, J. W. Thurburn, R. S. Maclagan, H. F. Chesney, D. Ogilvie, W. R. Morton, and W. Garforth, Lieut.-Colonels A. S. Holme and C. H. R. Chesney, and Major B. J. Haslam; and among those officers who served in the United Provinces, Major-General Sir Sydney Crookshank, Colonels J. A. Graeme and C. C. H. Hogg, Lieut.-Colonel P. G. H. Hogg, and Lieut.-Colonel W. de H. Haig, who is still in the Public Works Department. No story of road-making in Northern India would be complete without a reference to the 68 miles of roads of all sizes constructed or remade by Crookshank for the Delhi Coronation Durbar of 1911. A Delhi Durbar Committee assembled in 1910 with Colonel R. S. Maclagan as Public Works representative.[1] As such, Maclagan had to plan the general lay-out of all the roads, camps and water-supplies, which extended over an area of many square miles, and it was undoubtedly due to his successful management of the details of the Durbar that he became, in 1912, Chief Engineer in the Punjab—the post which his father, General Robert Maclagan had held some 30 years before.[2] But the burden of the actual construction work fell on Crookshank and his staff, who made the roads, buildings and grounds required for the great assembly, and prepared the huge amphitheatre on the site of the Durbars of 1877 and 1903.[3] The cost of these works amounted to more than 21 lakhs of rupees. The largest road—"The Mall"—was 50 feet in width, and there were many 40 feet wide. All the important

[1] "The Delhi Coronation Durbar, 1911," by Colonel R. S. Maclagan, C.B., C.S.I., late R.E., appearing in *The R.E. Journal*, Vol. XIX, January–June, 1914, p. 161.

[2] Memoir of Colonel R. S. Maclagan, C.B., C.S.I., C.I.E., appearing in *The R.E. Journal*, Vol. XLVI, March, 1932, p. 135.

[3] "Completion and General Report on Durbar Works, P.W.D., Delhi, 1911," by Major S. D'A. Crookshank, C.I.E., M.V.O., R.E., appearing in *The R.E. Journal*, Vol. XIX, January–June, 1914, p. 359.

roads were treated with oil to lay the dust. Along these magnificent thoroughfares passed the glittering escorts of Indian princes, and beside them toiled the creaking bullock carts of humble villagers.

After the Great War there was a boom in road-construction and repair, caused by a remarkable increase in motor traffic. "I returned to India in 1919," writes Lieut.-Colonel A. S. Holme,[1] "and was appointed Superintending Engineer at Rawalpindi. There had been great changes in the country during the intervening five years. Before the war, motor-cars were comparatively scarce; now they were to be seen everywhere, and they continued to increase in number. Roads began to be looked upon from quite a different standpoint: they had become extremely important for the development of the Province. The first big job that claimed my attention was the construction of a bridge of 17 spans, each of 145 feet, over the Chenab River at Wazirabad, and this was opened in 1922.[2] It was the largest work of its kind carried out by the Punjab P.W.D. I left India finally in March, 1929. These were years of comparative plenty, and considerable progress was made in pushing on with arterial roads." So it seems that modern India owes much to the noisy but highly efficient vehicles produced by Mr. Henry Ford. But very few Royal Engineers were concerned in these extensions and improvements of roads, for they may be said to have almost vanished from civil road-construction with the outbreak of the Great War. Their energies, as road-builders, were then transferred to the military roads on the North-West Frontier, where there is ample scope for ingenuity and enterprise.[3]

[1] Extracts from notes sent to the author by Lieut.-Colonel A. S. Holme, R.E. (retd.), in March, 1933. Colonel Holme served in the B. & R. Branch, P.W.D., Punjab, from 1897 to 1929, with intervals of military service.

[2] Until the present century the Grand Trunk Road was by no means an uninterrupted line of communication. The Ravi at Lahore was not permanently bridged until 1913. Work on the Wazirabad bridge began in 1919, and many bridges were built, or old ones strengthened, between 1920 and 1930. Limestone was introduced, instead of kunkur, for metalling.

[3] It may be noted, however, that from 1901 when the N.W.F. Province was formed, until 1932, when it became a "Governor's Province," the roads and buildings of the province were in charge of the Military Engineer Services, staffed by R.E. officers. The P.W.D. assumed charge in 1932.

CHAPTER V.

SOUTHERN AND CENTRAL ROADS.

THE construction of the first metalled roads in Northern India was a military precaution. As British influence spread towards the warlike North-West, and particularly after it had entered the Punjab, a good line of communication was needed for the rapid concentration of troops and supplies. This was the chief purpose of the Grand Trunk Road. Trade facilities, and any general improvement in the welfare of the inhabitants, were matters of secondary importance. In Southern and Central India, however, the situation was different, because the subjugation of the Mysoreans and Marathas had removed any likelihood of war on a large scale. No military roads were then needed in those parts of the country, and the requirements of administration and trade alone governed the construction of metalled highways. In the North, Government was forced to spend money on permanent roads : in the South, there was no such compulsion. So Madras, and the centre of India, though traversed in time by a few moderate roads and many bad ones, lagged behind Bengal in the rapid extension of satisfactory communications, for their roads were expected to show an early financial return for any money spent on them ; and because the southern half of India was more peaceful than the northern, fewer military engineers were concerned with the central and southern roads than with those near the Himalayas or on the borders of Afghanistan.

Lieut.-Colonel Arthur Cotton, M.E., the famous irrigation expert, had a poor opinion of the methods of road-construction in India generally, and particularly in the south. His criticisms are tinged with unnecessary sarcasm and bitterness, but they are instructive. Writing in 1854, he remarks :—[1]

"There cannot be any greater proof of the evil consequences of doing things without any general investigation than the history of communications in India up to this time, the desultory way in which the matter has been attended to, and the consequent failures and waste of money that we have seen. A sketch of our first attempts at road-making in the Madras Presidency may be of great use as a guide and a warning. It was assumed that all that was necessary

[1] Extracts from *Public Works in India*, by Lieut.-Colonel A. Cotton, M.E., p. 4, and from writings by Colonel Cotton quoted in *General Sir Arthur Cotton, R.E., K.C.S.I.*, by Lady Hope, pp. 206–208.

to successful road-making was a given number of men with tools in their hands, headed by an officer taken at random from the Line and without any scientific qualifications whatever. Bodies of Pioneers, thus equipped and commanded, were placed upon a line many hundreds of miles in length, and when it was found that but little impression could be made upon such a surface, the remedy was to add thousands of coolies, and thus, besides the cost of the Pioneers, lakhs of rupees were wasted in an attempt to do by mere labour what could only be effected successfully by labour under the direction of science.

"The first roads to be made were probably those in Tanjore.[1] When it was proposed to open one or two lines in that impassable sheet of irrigation, it was immediately objected, 'Well, this is a fine proposition, to make fine roads where there is not a horse or a cart to be found!' There was not a mile in the whole delta over which a horse and cart could have moved. After some struggling, however, a first attempt was made, and it was discovered that when there were cart-roads, carts were used. But what was done in Tanjore was done without the least reference to any other part of the country.[2] The questions were never asked, 'If roads are to be made, where are they most wanted? Where will capital so expended produce the greatest result? Which road ought to be made first?' Tanjore, possessing the most active Government officers, got roads; and the rest of the country remained generally without them, as it is to this day (1854).

"The next roads were probably those made by the Pioneers. The arrangements for these works were as follows:—Some lady in Madras having a favourite brother or cousin in one of the native regiments, took an opportunity at a pleasure ball given by the Quarter-Master-General, to ask him if he could not do something for her relation. Upon this he is put into the Pioneers, and in a few years he gets command of a battalion.[3] In the course of time, some great public functionary, being detained for weeks on an impassable line of country in his palanquin, becomes very sensible of the sufferings of the people in that neighbourhood from want of roads, and persuades Government to send a battalion of Pioneers to make one. The whole management of the work falls, of course, to the officer so carefully selected to command them. He has never seen a road made: he left England before he was old enough to entertain a thought about the roads he travelled over there. He has not an idea on the whole subject, or a book to refer to. Of the principles on which the lines should be selected, as well as those on which the

[1] In the early part of the nineteenth century.

[2] Meaning Southern India: not India as a whole.

[3] Up to the time of their abolition in 1834, the old Madras Pioneers were under the orders of the Quartermaster-General, although the Madras Engineers were under the orders of the Commander-in-Chief. (See Vol. I, Chapter XIII.)

roads should be constructed, he is as utterly ignorant as the lady who recommended him for his appointment. Lakhs of rupees are spent by a man who has not the slightest knowledge of, or even natural turn for, the work he is employed upon, and who possesses perhaps a low degree of general ability and zeal.[1]

"There is not the slightest exaggeration in this; it is a literal statement of the *usual* course of proceedings in times past. No check of the remotest kind was exercised over these works; not a single professional officer had anything whatever to do with them. The Quarter-Master-General, under whom they were carried on, was as perfectly ignorant of the matter, and probably at least as indifferent about it, as the Executive Officer. The road from Masulipatam to Hyderabad, a distance of 220 miles, was one of those executed in this manner. When about £80,000 had been spent upon it, besides the pay of the Pioneers, the Court of Directors put a stop to it, and, as no metal of any kind was put on most of it, the road has never yet been practicable in the wet season. Only about 120 miles were meddled with. The money spent was therefore nearly £700 a mile, or twice as much as would make an excellent road. The road from Madras to Poonamallee, 11 miles, was a similar case: £44,000 were spent here, or £4,000 a mile. The Court of Directors now saw it was necessary to apply a remedy, and it was to order that no more roads should be made. This was simple and effectual.

"Nevertheless, after some years (about 1839), another line of road was commenced by Government, and this time the most important direction in the Presidency was selected, viz., that leading from Madras directly into the interior, 120 miles. But exactly the same mistakes were made in its execution. It was put under a non-professional officer; not a single engineer was employed upon it; the line was badly selected; enormous labour was wasted on it, and it was not in any sense completed. This road cost 10,000 rupees a mile. It was, however, a work of immense value, imperfect as it was; there has been an enormous traffic on it, and it has saved in the cost of traffic much more than 100 per cent. on its cost.

"At length, something like a systematic attempt was made to introduce roads into Madras. A Road Department was formed with the approval of the Court, but the same error was committed of having no thorough investigation or open discussion. A professional officer was indeed appointed; but as he had charge of all the main roads of the Presidency, and had only two assistants, he was completely lost in his duties, and everything was still done in the same way without open discussion. Some work, however, was really done. The great road from Madras, above mentioned, was much improved and some other lines commenced. But now a new

[1] History does not support such a sweeping condemnation of the Pioneer officer. Many of these officers were both able and zealous; but they had not the technical ability and training of the Madras Engineers.

difficulty arose. The local Government would not sanction the expenditure which the Court had authorized; and the Superintendent of Roads was so cramped in every way that, though he wore himself out in his work,[1] but little was effected. The great line from Calcutta to the North-West (the Grand Trunk Road) is almost the only important work that has yet been executed, and after all it is but a common road. Some real progress has, however, been made of late years in the North-West in improving the roads."

These outspoken remarks and criticisms give in a nutshell the general history of road-construction in the Madras Presidency before the Indian Mutiny. It seems that, in those days, most officers of the Madras Engineers did not like this work, or if any liked it, they were not allowed to undertake it. Such employment was classed as "unskilled," and suitable only for Pioneers working under infantry officers, although there should have been enough Engineers available to survey and superintend the construction of all the main roads if their appointment for these duties had been considered advisable. So there is little to record of the achievements of military engineers in the construction of civil roads in Southern India until after the Indian Mutiny. These officers devoted their energies to irrigation work, the management of Mints, building construction, fortification and surveying, and to their military duties with the Sappers and Miners in Bangalore and occasionally on expeditions overseas. In fairness, however, to the much-maligned Pioneers, it should be recorded that, on active service in the jungles of Coorg, Madura and Travancore, they performed wonders in clearing tracks for military traffic. This was their proper duty: the design and construction of permanent civil roads should not have been demanded of them. A report by Captain William Murray, of the Madras Infantry, who commanded the last battalion of Pioneers in 1832, shows that his men had then developed considerable skill in making small hill-roads. "Since the period of the Governor's visit to the Koondahs," he writes,[2] "six miles of mountain road have been completed by the Pioneers, and every impediment surmounted, being a progress, I imagine, rarely equalled by any body of men of equal strength. This stupendous work, in which there were vast forest trees to be felled, deep chasms to be built up, causeways over every river and mountain torrent to be constructed, and rocks to be removed, was begun on January 10th and finished on May 31st, 1832." The work in the Kundahs formed a fitting close to the record of a gallant and distinguished Corps.

A map of the roads—unmetalled, of course—which existed in the

[1] Captain Samuel Best, M.E., the unfortunate Superintendent of Roads, died at Chittoor in 1851.

[2] Report by Captain Murray dated June 9th, 1832, quoted in *The Military History of the Madras Engineers and Pioneers*, by H. M. Vibart, Vol. II, pp. 84–85. The Kundah Ghats are in the Nilgiri Hills, west of Ootacamund.

Indian peninsula south of Nagpur in 1833,[1] shows that the country was well supplied with such thoroughfares except between the Western Ghats and the sea and between the Mahanadi and Godavari Rivers on the east coast. A road or track follows the western coast from Goa through Mangalore, Cannanore and Calicut almost to Cape Comorin; and along the eastern coast, another runs northwards through Palamcottah, Negapatam, Cuddalore, Madras, Masulipatam and Vizagapatam to Berhampore, whence it bears inland by Raipur to Nagpur. Only one road leads out of Bombay—that to Poona. The western ports below Bombay are connected with the interior by routes through the Ghats, for instance, Malvan is joined to Belgaum, Goa to Dharwar, and Mangalore to Seringapatam, but there are no lateral communications. Many roads radiate from Madras, and each of the large inland towns such as Poona, Hyderabad, Bellary, Bangalore, Seringapatam and Trichinopoly is the centre of a small web. The only area which seems to have no roads, except along the coast, is that between the Mahanadi and Godavari Rivers, the reason being that this country has so many rivers and tidal creeks that it was found to be cheaper and easier to transport goods by water than to make roads across the lines of natural drainage. As Chesney says,[2] "Not only does the construction of roads require a continued outlay, but every completed work involves a fresh and permanent charge for maintenance, which may be set down as £50 a mile." Madras could not afford the luxury of metalled roads outside her cities until several years after Bengal had begun to experiment with them.

"When England became the dominant power in India," writes Sir William Andrew,[3] "there never was a country so rich and intelligent in which roads were so few and travel so difficult. For the rich, the camel, the elephant, the horse and the palanquin; for the poor, the pony and the pack-bullock. These were the only means of conveyance by land. Only springless wheeled carriages called *ekkas*, drawn by horses and ponies, and bullock carts, could generally be used on a few of the main roads that might be enumerated on the fingers of one hand, or in the neighbourhood of populous towns. In the south-west of India, from November to June, small bullock carts could travel in certain districts on what have been called the 'natural tramways of the country,' otherwise in ruts, formed in black cotton soil, which after two days' rain became a morass, impassable for horses, difficult for bullocks and buffaloes; and such was frequently the distress of these animals that they sank under their burdens, and their bones, whitening the route, acted as

[1] A map by Captain W. J. Butterworth, A.Q.M.G., Madras Army, entitled *Table of Roads from Madras to the Principal Towns and Military Stations under the Presidency of Fort St. George*, 1833.

[2] *Indian Polity*, by Lieut.-Colonel G. T. Chesney, R.(B.)E., p. 374.

[3] *Indian Railways*, by Sir W. P. Andrew, C.I.E., 1884. Preface, pp. viii-x.

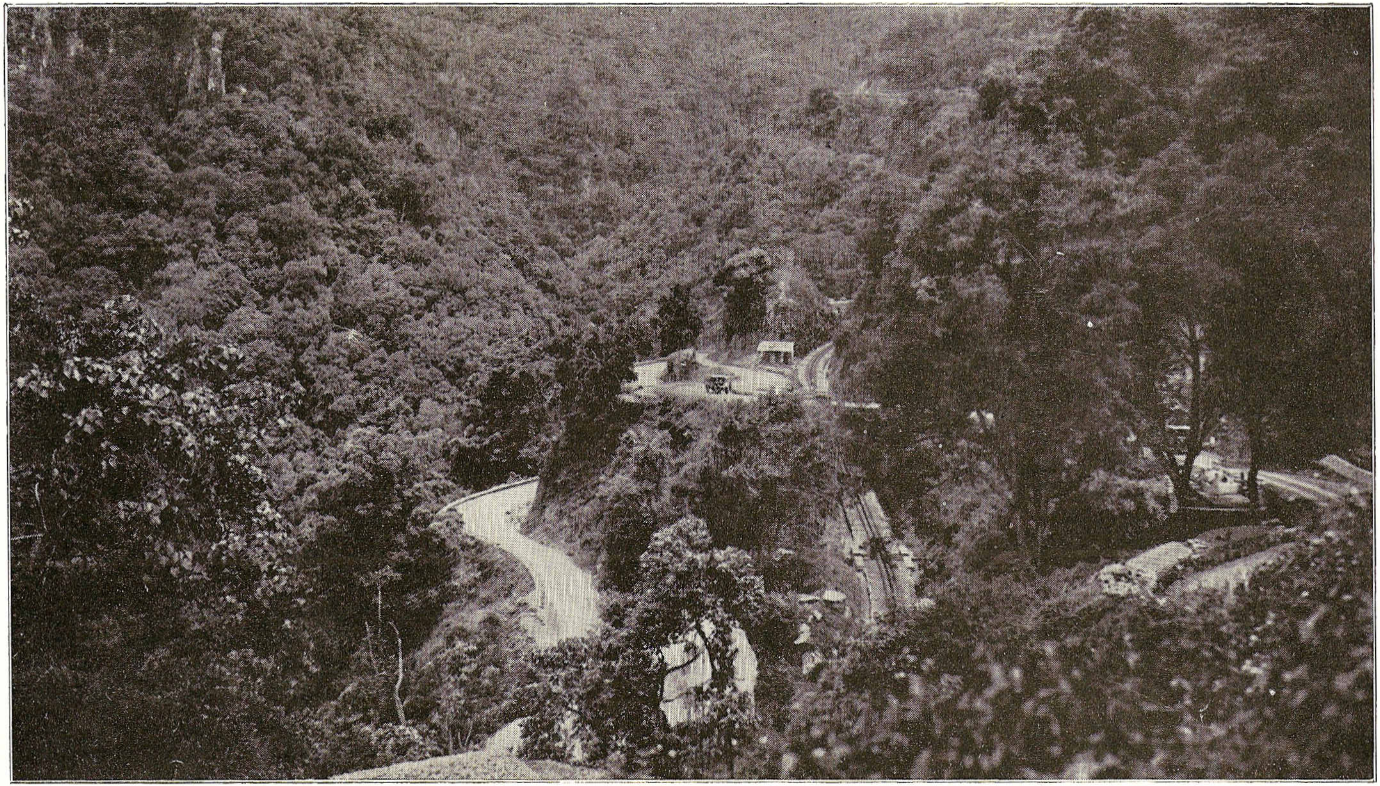
landmarks to travellers. Over thousands of square miles, wheeled carriages were unknown, and had never been seen by the oldest inhabitant. Wandering gipsy-like tribes, called Brinjaras, followed armies with stores, or carried salt, coarse sugar and grain on buffaloes and pack-bullocks during the open season. In the rains, from the middle of June to the middle of October, there was no traffic, there were no travellers." The first steps to alter these lamentable conditions were taken by the Pioneers and military engineers. Much of their work may have been ill-conceived and poorly executed, but it laid the foundations of a great system.

During the military operations in 1834 in the Coorg District, west of Mysore, the Madras Sappers and Miners under Captain (afterwards Major-General Sir Thomas) Pears, M.E., had much road-making to do in the jungles of the Western Ghats, these roads being, of course, mere tracks through the dense forest. "It was not till three years after the British had possessed themselves of the country," says Major Sankey,[1] "that the impossibility of moving a force into South Coorg, to subdue a rebellion which had sprung up there in 1837, showed the absolute necessity of constructing some kind of military road, and the Sumpagee Ghaut was made by Lieutenant R. F. G. Fast, M.E. The Anachowkoor road and Periambady Ghaut were finished some 12 years later by Lieutenant P. M. Francis, M.E., as a military necessity, the old line to Cannanore through Wynaad and the Perriah Pass proving altogether impracticable. The connecting road between Mercara and Veerajendrapett, with a similar military object, was made soon afterwards. At this moment (1866) these three military roads remain practically the only ones devoted to wheeled traffic in the country, and it will be seen that even these, masterpieces of engineering as they were when first driven through almost impenetrable forests, are in many places quite unsuited to the requirements of the cart traffic which has now set in upon them. The Sumpagee Ghaut, 19¼ miles in length, and leading direct to Mangalore, the first of the 14 or 15 roads now carried through the Western Ghauts, is undoubtedly the best in Coorg." In 1866, the Sampaghi (Sumpagee) road was about 21 feet wide, and surfaced with laterite gravel or stiff gravelly clay; it descended from Mercara, 3,000 feet above the sea, to Sampaghi at the foot of the Ghat on a gradient of about 1 in 20,[2] and is a good example of the fair-weather roads which were made by the British before metalled highways were provided.

The network of first-class metalled roads which now covers Southern India has been planned and made almost entirely by civil

[1] Article entitled "Roads in Coorg," by Major R. H. Sankey, R.E., Assistant to the Chief Engineer, Mysore, appearing in *Professional Papers on Indian Engineering*, Vol. III, 1866, No. CXII, p. 224.

[2] Article entitled "Road Tracing in South Canara," by an officer of the Madras Engineers, appearing in *Professional Papers on Indian Engineering*, Vol. III, 1866, No. CIII, p. 118.



THE NILGIRI HILL-ROAD AND RACK RAILWAY TO OOTACAMUND.

engineers. By the year 1870, 1,800 miles of roads, of which more than 500 miles were metalled, had been constructed in Mysore alone. Many fine bridges were built as the roads were extended, one of the most remarkable being the Palamcottah Bridge across the Tambraparni River in the Tinnevelly District not far from Cape Comorin. This masonry structure, which was completed as early as 1843, consisted of 11 elliptical arches, each of 60-feet span and 17-feet rise, and the design is said to have been copied from that of Waterloo Bridge over the River Thames.[1] It would be superfluous, however, to attempt to trace the gradual expansion of the Madras system of roads. In pre-Mutiny days, Lieut.-Colonels A. Lawe and C. E. Faber, M.E., Chief Engineers in the Southern Presidency, had a considerable share in this work, and also Major T. T. Pears and Captain C. C. Johnston, M.E., both of whom became Consulting Engineers for Railways. After the Indian Mutiny, Lieut.-Colonels C. J. Greene, A. J. M. Boileau, E. Lawford, R. Henderson, W. I. Birdwood, G. W. Walker, J. C. Anderson, C. V. Wilkieson and R. H. Sankey, as Chief or Superintending Engineers, P.W.D., were concerned with road development; but by 1870 most of the military engineers of Southern India had handed over this work to their civilian brethren.

Western India was traversed by several ancient routes before the British set foot in the country. One of the most important was the Ajunta Road to Asirgarh, leading from the Deccan to the north and fed by three main lines from the coast. The first coastal connection ran by the Nana Ghat to Junnar and Paithan in the Aurangabad District; the second by the Malsej Ghat to Utar and thence to Paithan; the third by the Bhor Ghat to Poona and Ahmadnagar, the Bhor Ghat being the easiest of the coastal passes, although unfit for carts.[2] All these, of course, were unmetalled. It was not until 1803 that the first impetus to British road-construction was given by Colonel Arthur Wellesley, afterwards the Duke of Wellington, when he set his military engineers and Pioneers to construct a fair-weather road up the Bhor Ghat to facilitate the reinforcement and supply of his armies in the Deccan during the Second Maratha War. This road helped materially towards the success of Wellesley's operations, but afterwards it fell into disuse and was destroyed by the Peshwa. In Bombay itself, at the beginning of the nineteenth century, the streets and roads were narrow, insanitary and unmetalled. Little was done to improve them, and until a Surveyor of Roads was appointed in 1808, the Superintendent of Police had charge of them. But a marked change occurred before 1832, when good roads existed throughout Bombay Island, and the main thoroughfares were described as "beautifully macadamized," while in 1838 they were

[1] *Ways and Works in India*, by G. W. MacGeorge, p. 95.
[2] Pamphlet entitled *Ancient Sites near Ellora, Deccan*, by K. de B. Codrington, Indian Section, Victoria and Albert Museum, London.

said to be "watered, tolerably lighted, clean and void of all offence."[1]

Communications between Bombay and the interior were greatly improved between 1819 and 1827 by Governor Mountstuart Elphinstone, who decided to reconstruct Wellesley's road up the Bhor Ghat, and set his Engineers and Pioneers to do it with the help of large gangs of workmen. According to Bishop Heber, who arrived in Bombay about 1825, a tolerably good but unmetalled road was then being made.[2] "From Campoolee I walked up the Bhorel Ghat four and a half miles to Khandalla, the road still broad and good, but in ascent very steep, so much so indeed that a loaded carriage, or even a palanquin with anybody in it, can with great difficulty be forced along it. In fact everyone walks or rides up the hills, and merchandise is conveyed on bullocks and horses. The ascent might have been rendered, by an able engineer, much more easy. But to have carried a road over these hills at all, considering how short a time they have been in our power, is highly creditable to the Bombay Government." The work begun under Elphinstone was finished in the time of his successor, Sir John Malcolm, who opened the Bhor Ghat road on November 10th, 1830, when it was being metalled and so nearly completed that he was able "to drive down with a party of gentlemen in several carriages."[3] As the seaward part of a road up the Thal Ghat had already been put in order by the Pioneers during the year 1826, the communications between Bombay and the Deccan were then more satisfactory. During the first half of the nineteenth century, the military engineers of Bombay were concerned also with the construction of two great causeways which served the double purpose of reclaiming land from the sea and carrying traffic. These were the embankments of Sion and Mahim. The first was built between 1798 and 1805 by Captain W. Brooks, Bo.E., and enlarged by Captain W. A. Tate, of the same Corps, in 1826; the second was designed by Lieutenant A. Crawford, of the Bombay Infantry, in 1843, constructed by Captain J. J. F. Cruickshank, Bo.E., and opened to the public in 1845.

The means of conveyance in Bombay improved with the roads. It is recorded that when Admiral Watson came to the city in the middle of the eighteenth century, his suite were given palanquins, while he himself was allotted a "hackery drawn by bullocks of uncommon speed and endurance." A hackery, according to the *Bombay Quarterly Review* of 1857,[4] "had no resemblance to those neat carts of painted wood and cane work, with springs and patent axles, which are now manufactured for European comfort in the *mofussil*, but was a contracted canopy of cloth on wheels, such as

[1] Hill's *Voyages*, p. 7.
[2] *Gazetteer of Bombay City and Island*, Vol. II, p. 141.
[3] It seems that most of the construction of the Bhor Ghat road was carried out by a contractor, Captain Hughes.
[4] *Bombay Quarterly Review*, 1857, Vol. IX, p. 163.

the humbler class of Banians use. In this the distinguished visitor crouched as his cattle jogged along, now in a trot and again in a short jerking gallop, at the rate of seven or eight miles an hour. He tucked up his legs as best he could; but after all his pains, they were more or less bespattered with filth." And writing of the Bombay palanquin in 1813, Maria Graham says:—[1]"These palanquins are litters in which one may either lie down or sit upright, with windows and sliding doors. The modern ones are little carriages on wheels. Those anciently used were of different form and consisted of a bed or sofa, over which was an arch just high enough to admit of sitting upright; it was decorated with gold or silver bells and fringes."

When Wellesley's engineers were making the first British road up the Bhor Ghat, horse-drawn vehicles began to replace bullock-carriages and palanquins, and in 1807 Bombay had coaches, phaetons and buggies. Forty years later, the buggy was the most popular conveyance, but in 1863 the *shigram* had become the favourite—a curious vehicle described by Lieutenant A. M. Lang, B.E., as a kind of palanquin on wheels with a striking family likeness to an English bathing machine.[2] In 1882 came the "Victoria," and about 1900 the motor-car. Thus the speed and comfort of travel in Bombay kept pace with the growth of the roads.

The decade 1860 to 1870 marks the point at which most of the broad modern thoroughfares of Bombay Island were planned and made, no less than 35 of these roads being completed in that period. It is interesting to note that steam-rollers were first used in Bombay, for the consolidation of the road-metalling, in 1869. Useful work was done by Captain W. D. Graham, Bo.E., in the 'forties and early 'fifties when he was Superintendent of Roads and Tanks under Colonel G. R. Jervis and afterwards under Colonel C. Waddington (Chief Engineers); but the true development of roads began under Colonel (afterwards General) Walter Scott, who was Chief Engineer after the Indian Mutiny when Colonel (afterwards General) H. B. Turner held a similar post in Sind. In 1863 came Lieut.-Colonel (afterwards General Sir Michael) Kennedy as Chief Engineer of the Bombay Public Works and Railways Department, Colonel (afterwards Lieut.-General) C. W. Tremenheere being then Chief Engineer in Sind. Of all these Bombay Engineers the most distinguished was Kennedy, who was Chief Engineer and Secretary to Government for 16 years until he became Controller-General of Supply and Transport in the Second Afghan War in 1879.[3] Kennedy, though naturally more interested in railways than roads, was the moving spirit in the extension of the latter during his long connection with the Bombay Government. Colonel H. D. Olivier, late R.E., a noted *shikari*

[1] *Journal of a Short Residence in India*, by M. Graham, 1813.

[2] "Diary and Letters of A. M. Lang," appearing in the *Journal of the Society for Army Historical Research*, Vol. IX, April, 1930, p. 96, footnote.

[3] See Vol. I, Chapter XIX.

whose collection of trophies has been the envy of many sportsmen, states that when he joined the Bombay P.W.D. in 1875 almost all the officers of the Department were Royal Engineers;[1] he adds that the head of the Department was Sir Michael Kennedy, "a very able man with great force of character," and that the best Executive Engineer under whom he served was Colonel W. M. Ducat, who was employed in the Kholapur State, and there carried out many fine works, in some of which Olivier shared.[2]

Other Royal Engineers who served in the Bombay P.W.D. and were concerned to some extent with road development in Western India were Colonels A. Cowper, J. A. Fuller, C. J. Merriman, C. A. Goodfellow, V.C., J. D. Cruickshank, F. M. Westropp, W. V. Scudamore, and, latterly, D. S. Johnston, C.I.E., Chairman of the Aden Port Trust in 1933. Scudamore writes[3] that, when he joined the Department in 1892, J. D. Cruickshank was a Superintending Engineer, but that almost all the other Royal Engineers had then been transferred to the Military Works Department. Thus the connection of the Corps with important road-construction in the Western Presidency practically ceased some 40 years ago. The magnificent trunk lines from Bombay through Nasik and Indore, and from Bombay to Poona and thence southwards through Dharwar, south-eastwards through Sholapur, and north-eastwards through Aurangabad, were certainly begun by military engineers; but they were completed by civil engineers, to whom the chief credit must be given for the excellence of their design and alignment.

In 1840, soon after the construction of the Grand Trunk Road had been started from Calcutta, several military engineers began to build another trunk line from Agra to Bombay, a distance of 735 miles. They took it, at a total cost of a quarter of a million sterling, through Gwalior, Indore, Mhow and Dhulia to Nasik, and it reached Bombay by the Thal Ghat. The construction of an indirect line of communication between Bombay and Calcutta (1,170 miles) was begun in 1842 and completed before the Indian Mutiny. Part of this route was the "Great Deccan Road," which left the Grand Trunk Road at Mirzapur on the Ganges, and, running thence by Rewah to Jubbulpore, connected with Nagpur and Bombay. By the year 1870, communication had been established between Calcutta and Madras by a south-eastern coast road through Midnapore, Balasore, Cuttack, Vizianagram and Guntur, and secondary roads were being made throughout the whole of India to join the trunk roads to railway centres.

The Central Provinces naturally lagged behind the remainder of India in road development as they were not amalgamated under

[1] Letter from Colonel H. D. Olivier, late R.E., to the author, dated May 2nd, 1933.
[2] Olivier was in direct charge of many other large works.
[3] Letter from Brig.-General W. V. Scudamore, late R.E., to the author, dated April 22nd, 1933.

British rule until 1861. It is said, indeed, that in 1862 these Provinces had barely 20 miles of first-class road.[1] During the following 12 or 15 years, however, several excellent lines of communication were made, such as a northern line from Nagpur by Seoni to Jubbulpore (185 miles), an eastern line from Nagpur through Bhandara and Nandgaon to Raipur, and other lines from Jubbulpore through Damoh to Saugor, and from Saugor to the Narbada Valley near Narsinghpur. The road between Nagpur and Jubbulpore was for many years a most important link in the route to Upper India, as it connected the railway termini at those cities before the difficult section of railway line along the Narbada Valley between Khandwa and Jubbulpore was built. This road contains many fine engineering works, such as the Kanhan River bridge near Kamptee, ten miles north of Nagpur, a masonry structure, 1,300 feet long, with 12 flattened arches, each of 80-feet span, which was completed in 1873 at a cost of nearly £110,000. At about this period an excellent main road was made through the Native States of Central India, beginning from Muttra near Agra and running southwards by Jaipur, Ajmer, Nimach and Ratlam to join the Bombay-Agra Road near Indore; and in more recent times a direct connection was provided between Bombay and Calcutta by the extension of the route through Aurangabad, Nagpur and Raipur to Sambalpur and Midnapore. Enough has now been written of the trunk roads of India. They form a vast web of metalled highways. Beginning with the Grand Trunk Road from Calcutta to Delhi, this web was woven gradually over the face of the country during the latter half of the nineteenth century. It has contributed largely to the success of the Indian railway systems, and has brought prosperity to millions of cultivators.

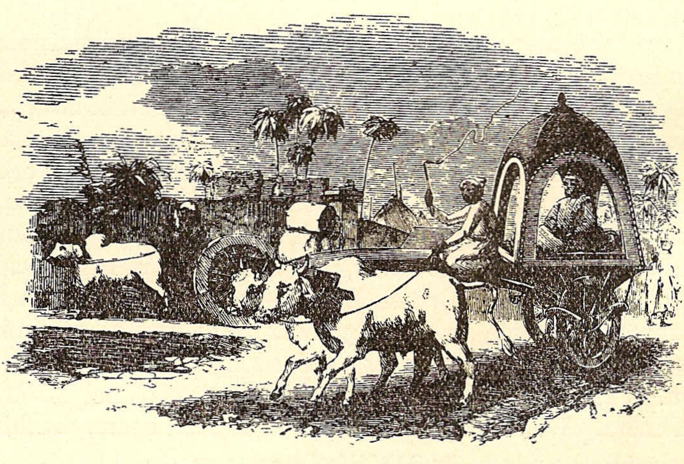
While the military and civil engineers were covering India with communications, Burma had to wait for her "Road to Mandalay"; yet she deserved her share of highways, for she is rich in minerals and her area is enormous. The present Bishop of Norwich tells a story of a schoolmistress who informed her pupils that "Upper Burma alone is about as big as Siam," and was astonished to find afterwards that half the class had written in their notebooks "Upper Burma is about as big as *she* is." However, it is a fact that in 1870 there were only two main roads in British Burma—one from Rangoon northwards through Prome to Meaday near Thayetmyo, 215 miles in length, and the other, a branch, 35 miles long, from the Prome Road to Pegu.[2] The Chief Engineer at that time, Colonel (afterwards Major-General) W. S. Oliphant, late Bengal Engineers, did his best

[1] *Ways and Works in India*, by G. W. MacGeorge, p. 90.

[2] In 1825, however, during the First Burma War, a road, still known as "Meade's Road," was made down the Arakan Coast to Maungdaw and thence over a pass to Buhtidaung. The builder was possibly Lieut. E. Meade, Bengal Infantry, working in collaboration with Lieut. George Thomson, B.E., or Capt. Wilkie, Bengal Pioneers. (See Vol. I, Chapter XIV, p. 258.)

to open up road communications, though much hampered by natural obstacles and the competition of boat traffic by the Irrawaddy. His efforts met with some success, and he records that, when he travelled in 1874 along a newly-made stretch of road which in 1869 had traversed a wilderness of elephant grass and jungle, he noticed that the development of rice cultivation since the construction of the road had been marvellous. "The natives," he adds,[1] "are flocking to the district as settlers, the wilderness has ceased to exist, and in a short time it will be almost an unbroken sheet of cultivation. It is noticeable that, wherever our road is at all approaching completion, villages spring up and vegetation commences." Burma still has few main roads beyond the vicinity of her large towns. The Rangoon-Pegu Road had been prolonged up the course of the Sittang River to Toungoo; and the Rangoon-Meaday Road, now lengthened to Mandalay, has thrown out a branch from Meiktila through Myingyan to Yeu and Shwebo, north of Mandalay. But Upper Burma has to rely chiefly on a single line of metre-gauge railway to Myitkyina, and there is much need for road development to supplement river traffic. The Bengal Engineers, however, who made the first roads from Rangoon up the Lower Irrawaddy and to Pegu after the Second Burma War, laid the foundations of what may yet become an extensive system of communication, to be linked, perhaps, at some future date, with India, through the formidable mountain barriers which intervene.

[1] *Indian Public Works*, by W. T. Thornton (1875), p. 59.



HACKERY AND DOOLY.

CHAPTER VI.

BUILDINGS.

We build 'em nice barracks—they swear they are bad,
That our Colonels are Methodist, married or mad.
—RUDYARD KIPLING (in " Sappers ").

UNDAUNTED by much undeserved criticism, the military engineer in India has always been a builder, and still continues modestly in that trade. He is now rarely called upon to design and erect great structures such as Government offices, High Courts, palaces for Viceroys, Governors and Princes, or cathedrals and churches. These come within the domain of the civil engineer and the qualified architect ; but it was otherwise in the olden days, when there was no one except the soldier to lay one stone upon another. In those times, when the East India Company decided to establish any small factory on the coast, their servants at once demanded a fortified enclosure, a Factors' house, warehouses, wells and barracks. Then they asked for a magazine, a hospital and a church. All fell to the military engineer to build in the intervals between private trading and fighting the " Moores " and pirates. He was often a simple " Gunner " without engineering training or experience, and he did the work in his own time and in his own way. Next came a few adventurers from England and elsewhere, who said that they knew something of building and architecture ; then certain military engineers who had been instructed in these branches of their profession ; then the excellent products of Addiscombe ; then Royal Engineers, experts in field engineering and fortification, and with a considerable knowledge of building ; and finally the civilian engineers and professional architects of the present day. All these have helped to build British India.

The pinnacle of constructional achievement, however, may be said to have been reached in modern times in the building of New Delhi at a cost of between ten and twelve millions sterling. Here the Government has abandoned its habitual architectural modesty, and has emulated the marvels of the Mughal dynasty by laying out a vast official city—the eighth Imperial Delhi—over an area of many square miles. The builders of New Delhi have just cause to be proud of their work, but the following tale may be good for their souls. A small English boy, the author's son, was once shown the wonders of their Great White City—the Secretariat, the Council Chamber, the Viceroy's palatial residence, the Memorial Arch, and

the gigantic avenues. He seemed, at the time, to be much impressed; but when he was taken to an hotel, and saw for the first time a porcelain bath with hot- and cold-water taps and a plug, he bubbled over with enthusiasm. "Of all the things I have seen to-day," said he, "*this* is the most interesting." Perhaps the Great White City is equally unlikely to impress the humble Indian villager with a sense of British power. But the constructional monuments to British rule in India are to be found mainly in the humbler public buildings with which every large station is liberally supplied, and many of these give evidence of the labours of the military engineers of the last century. They form the foundation, as it were, on which the pinnacle of New Delhi has been raised.

The earliest buildings, of any considerable size, to be erected by the British in India were located in Fort St. George at Madras. After a Fort House, warehouses and barracks had been built within the walls by Gunners Jeremy Roote and Hugh Dixon and their sailors, and when the settlement was extending beyond the fortifications, one William Dixon was appointed "Chief Gunner and Ingenier" and is believed by some to have projected the construction of the first Protestant church in India.[1] A site was selected under the southern curtain of the Inner Fort, and when £322 had been collected, William Dixon began his task in 1678 and completed the building of St. Mary's Church in 1680. The church had a nave and two aisles, a tower and a spire. The outer walls were made four feet thick to resist cyclones and bombardments; and brick arched roofs, two feet thick, were provided over the nave and aisles. The interior was 86 feet long and 56 feet wide. St. Mary's Church still exists, but it has had a chequered career and is considerably altered. When the French took Madras in 1746, they used the church as a reservoir for fresh water; it was converted into a barrack for British soldiers in 1758; and in 1782 it became a granary to hold reserves of food when the Mysoreans threatened to besiege Fort St. George. The building of this church in Madras inspired the Company's servants in Bombay to emulate a good example, and the Court of Directors helped the Bombay Council to collect money. It seems, indeed, that the Directors left no stone unturned, for a Court Minute of 1685 runs:—"Resolved that such Gentlewomen as shall be permitted to go for India, be obliged to pay £10 apeece on the Day of their respective Marriages towards finishing the Church now building at Bombay." The revenue derived from this source is not recorded, but the Bombay church was not built until 20 years later owing to local quarrels.

The construction of an arsenal in Fort St. George was completed

[1] The Rev. Frank Penny, however, in *The Church in Madras*, p. 81, states that the designer and builder may have been Edward Fowle, a Master Gunner. Penny records that the first church to be built in India was the Roman Catholic Church of St. Francis at Cochin. This was constructed by Albuquerque's Franciscan friars, and other Portuguese, between 1503 and 1524.

in 1772 under the superintendence of Lieut.-Colonel (afterwards Major-General) Patrick Ross, M.E. It comprised two blocks at right angles to each other, and cost no less than £11,000. Ross came under severe criticism for the design, which was peculiar in many ways, and he was blamed for ornamenting the exterior with a hybrid type of decoration much favoured by the old Nawabs of Oudh in Lucknow. So peculiar were the engineering arrangements in these days that this large work was entrusted to one John Sullivan, a contractor only 22 years of age, who had less than six years' experience of India. A more satisfactory undertaking was the building of St. George's Cathedral, a stately pile in Mount Road, with lofty porticoes supported by massive columns. It was designed at the beginning of the nineteenth century by Captain (afterwards General Sir James) Caldwell, M.E., and built by Captain T. F. de Havilland, of the same Corps, who completed it in 1815. The interior conveys an impression of light and space, and a double row of 18 pillars adds greatly to the artistic effect, which is heightened by an arched ceiling, beautifully decorated in raised plaster. De Havilland followed up this success by designing and building St. Andrew's Presbyterian Church on a circular plan, with a floor paved with black and white marble and a lofty central dome supported by 12 Ionic pillars. The foundation stone was laid in April, 1818, and the church was used for the first time in February, 1821. De Havilland constructed other buildings in Madras, and also a sea-wall, and deserves accordingly to be recognized as one of the leading engineers of his day in this department of his profession.

In the time of the Military Boards, the engineers of Madras were often hampered in their work by the cumbrous machinery of the old administration, and some of the history of their troubles makes entertaining reading. Sir Arthur Cotton, ever satirical, quotes the "Great Putty Case" as a typical example of the red-tape methods of the so-called good old days. In spite of his disclaimer, one is inclined to suspect some exaggeration, but his tale is amusing. Here it is, in somewhat abbreviated form :—[1]

The Great Putty Case.

"A range of barracks is built by an Engineer at a cost of £30,000 or £40,000 ; there is a large saving on the estimate sanctioned, for which he receives the thanks of the Court of Directors. Some time afterwards, a storm occurs which breaks a few panes of glass valued at £7. The heads of that division of the Army are directed to assemble a committee of officers to investigate the matter. Their report is referred to the Military Board, who forward all the documents to the Governor-in-Council with a deliberate and elaborate

[1] *General Sir Arthur T. Cotton, R.E., K.C.S.I.*, by Lady Hope, pp. 204–206.

report. They conclude that the cause of the windows being broken is the quality of the putty used, and that therefore, the Engineer ought to pay for them.

"All the papers connected with this intricate and vital matter are now examined by the Secretary to Government, who sends them in circulation to the Governor and the three Members of Council; and the important day at length arrives when the whole is to be reviewed and discussed in Council. The Government Secretaries are summoned, and a solemn investigation is proceeded with upon which the fate of £7 depends. After much discussion it is decided that the Secretary shall draw up a report embodying the opinions of the Council, to be submitted, with all the important documents connected therewith, to the Honourable Court of Directors and the Board of Control. After many months, during which the papers have been the frequent subject of communication and discussion among the secretaries, directors, etc., etc., in London, a steamer proceeds to India with the freight of these papers, greatly increased in bulk. They reach Madras; the Council is again assembled; the despatch is considered; a copy, with resolutions, etc., is sent to the Military Board; and after having been circulated, considered and discussed by them, instructions are issued announcing that the Honourable Court, of course with the concurrence of the Board of Control, have decided, for reasons duly stated, that the windows shall be mended at the expense of the Engineer.

"In the meantime, as the officer is not in India, the matter lies over for a year or two. On his return, being surprised at the receipt of these orders, he addresses the Chief Engineer, giving him, in a few words, reasons why he ought not to be held responsible for the loss of £7. The Chief Engineer draws up a minute on the subject, which is laid before the Military Board, who again consider the question and once more report to Government. The Governor records a minute, the Second Member of Council minutes, the Third Member minutes, the Governor winds up by a fourth minute. Again the Council assemble, consider, decide, and issue instructions to the Military Board, and finally the officer is told that he may keep his £7. And so ends the affair till the report of the Governor-in-Council reaches the Court, when they will possibly order the matter to be taken up *de novo* and thoroughly investigated. It should be mentioned that it was found at last that some brads had been omitted in fixing the glass, which was not likely to be discovered either by the President of the Board of Control, the 24 Directors and their Secretary, the Governor and Council of Madras and their Secretaries, the Military Board, the Chief Engineer, the General of the Division, the Committee of officers, or the Engineer himself, as none of them had ever served an apprenticeship to a glazier. This is the literal history of an Indian question which has recently been agitated."

After the Indian Mutiny, when civil engineers began to enter the newly-formed Public Works Department in steadily increasing numbers, the activities of military engineers were diverted more and more from civil work. The reorganization and redistribution of the Indian Army necessitated the building of new cantonments and the extension of old ones, and such projects were naturally allotted to soldiers. Yet the military engineer was still employed for a time in most of the large civil stations, and particularly in Southern and Western India, which were not much affected by the rebellion. He continued to erect public buildings, and he did it economically and well. The offices of the Mysore Government, which were designed and built by Lieut.-Colonel (afterwards Lieut.-General Sir Richard) Sankey, R.(M.)E., between 1864 and 1868, are a good example. " For some 37 years prior to the construction of the new range of buildings," writes Sankey in 1873,[1] "the Chief Offices of the Mysore Administration were located in the Fort at Bangalore and in hired houses. Sir Mark Cubbon had continued till his retirement in 1861 to hold his office in the ancient palace of Hyder Ali in the Fort, and notwithstanding the native inscription on this building, declaring it to be the 'admiration of the heavens,' nothing probably showed more conclusively the stern economy of the old Commissioner's administration than the fact of his consenting, year after year, to transact business in this singular old structure. The extreme inconvenience of the main building; the fears of its sudden collapse, the distance from the station, and the nuisance of scattered offices led at length in 1857 to the submission of a project embracing all headquarter offices under one roof; but the Mutiny interfering, it was not till 1860 that the first design went up to the Government of India. This, however, was rejected, and after much discussion a revised design by the writer was accepted and carried into execution." These offices, which cost more than 3½ lakhs of rupees, consisted of a double-storeyed block, 636 feet in length and 68 feet wide, the lower storey being built in stone and the upper in brick, and the whole plastered. Verandahs surrounded both floors, and the flat roof was terraced.[2] The design is typical of many buildings constructed in Southern India at this period by military engineers.

We turn now to take a brief glimpse at Bombay City. One of its most interesting buildings is His Majesty's Mint, the superintendence of which has rested since 1853 with officers of the Royal or Company's Engineers. The erection of this Mint was sanctioned by the East India Company in 1823, and it was designed and built between 1824 and 1829 by Captain John Hawkins, of the Bombay Engineers, in the form of a quadrangular structure of two storeys, situated near the

[1] Article entitled " Offices of the Mysore Government at Bangalore," by Lieut.-Colonel R. H. Sankey, R.(M).E., appearing in *Professional Papers on Indian Engineering*, 2nd Series, Vol. II, 1873, No. LXII, pp. 1–3.

[2] A layer of lime concrete on stone slabs, supported on wooden joists and beams.

present Town Hall and the Arsenal on ground which was originally reclaimed from the sea. On the upper floor were offices for the Mint Master and the Assay Master, while the ground floor was occupied by the Bullion Department. The original Mint has been improved and extended during the last 100 years by a long succession of military engineers until it is now a model of up-to-date efficiency. Another large building, which is the work of a military engineer is, the Town Hall. The idea of erecting a Town Hall was first mooted in 1793, and lotteries were raised in later years to obtain the necessary funds. By 1820 enough money had been collected to make a beginning, but not to carry on the work properly, so Government stepped in and finished it at a cost of more than six lakhs of rupees. In this case the designer was Colonel T. A. Cowper, late Bo.E., who died in 1825, eight years before the work was completed by other military engineers. Many years later, the Bombay Secretariat was planned by Captain (afterwards General) H. St. C. Wilkins, Bo.E. This is an imposing building in Venetian-Gothic style, 443 feet in length, with two wings each 81 feet in breadth; it faces Back Bay in a line of other fine buildings. It was built by Lieut.-Colonel (afterwards General) J. A. Fuller, R.(Bo.)E., who began his task in April, 1867, and finished it in March, 1874, at a cost of 12½ lakhs. Within the next five years, Fuller designed and built the High Court in Mayo Road—a building, 562 feet long and 187 feet broad, which is in Early English-Gothic style and cost 16½ lakhs. He also planned and constructed many other buildings.[1] In these and other works military engineers have left their mark in Bombay. The adoption of modified Gothic designs is surprising, as such architecture is unsuited to Eastern countries and is rarely found in India except in ecclesiastical buildings. Fuller and Wilkins, however, were not bound by convention, and their products are striking in appearance if slightly at variance with modern practice. Wilkins shone more as a designer than a builder, Fuller more as a builder than a designer.

And now to Northern India, where the work of some military engineers in old Calcutta claims attention. A petition was presented to the Council in 1776 for a proper church in place of the room in Old Fort William which was then used for divine service, but nothing came of it until the year 1783, when preparations were made to acquire a site. A great lottery, in the following year, resulted in the collection of 30,000 rupees, and an architect was

[1] Besides the High Court, Colonel Fuller, as Civil Architect of Bombay, designed and built the Goculdas Tejpal Hospital, the bell-chamber and steeple of St. John's Church at Colaba, the Ophthalmic Hospital, the Incurable Hospital, and the central portion of the Jamsetji Jijibhoy Hospital at Byculla. In addition to the Bombay Secretariat, he built, from the designs of others, the Public Works Offices, Post Office, Telegraph Office, University Hall, Library and Clock Tower, Sailors' Home, School of Art, Elphinstone High School, Elphinstone College and the Victoria and Albert Museum. These entitle him to be considered as the leading constructional engineer of his day in Bombay. (See the obituary notice of General J. A. Fuller, C.I.E., in *The R.E. Journal*, Vol. 32, 1902, p. 223.)

selected in the person of Lieutenant James Agg, of the Bengal Engineers. Agg designed a large square building with Grecian columns, a flat roof, a tower, and a stone spire, 174 feet high, and he was occupied for three years in erecting this edifice. St. John's Church, as it was named, was consecrated on June 24th, 1787, in the presence of the Governor-General (Lord Cornwallis), his officials, and " a very numerous and respectable company of ladies and gentlemen."

The next large civil work in Calcutta, in which a military engineer figured, was the building of a Government House in place of one hired from the Nawab of Chitpore. Lord Wellesley had written, as Governor-General, to the Court of Directors that, " India should be governed from a palace, not from a counting-house ; with the ideas of a Prince, not with those of a retail dealer in muslin and indigo." Being allowed to go forward with his scheme, he issued orders in 1798 to Captain Charles Wyatt, B.E.,[1] and Mr. E. Tiretta, the Company's Civil Architect, to prepare plans for a suitable building. Wyatt's design was accepted in the following year, and Colonel (afterwards Lieut.-General) W. N. Cameron, late B.E., who was the Chief Engineer at the time, furnished an estimate amounting to about £66,000. " Captain Wyatt's design," says the late Lord Curzon,[2] " was adapted from the plan of my own home, Kedleston Hall in Derbyshire, which was built for my great-grandfather, the first Lord Scarsdale, by the famous architect, Robert Adam, in the years 1759–1770." Construction began in Calcutta in February, 1799, and was completed in January, 1803. This Government House is Wellesley's chief monument in Northern India.

The inhabitants of Calcutta having decided in 1805 that they required a Town Hall, and the necessary funds having been raised by a lottery, the Government selected Lieut.-Colonel (afterwards Major-General) John Garstin, B.E., to design the building. Garstin planned a fine double-storeyed edifice in the Doric style, with a magnificent flight of steps leading to a grand portico on the south side. A room, 172 feet long and 65 feet wide, ran from end to end of the upper floor, and below it was another on the ground floor. Adjacent to these great halls were a number of smaller rooms and vestibules. The design was ambitious and well-considered, and was duly accepted ; but, for some reason, the progress of construction was very slow, and it was not till 1813 that the building was ready for use.

The most famous architect in old Calcutta, however, was certainly Captain (afterwards Major-General) W. N. Forbes, B.E., who gave the city both a Mint and a Cathedral. " There are really two Mints,

[1] Wyatt entered the Company's service as an infantry officer, but was transferred to the Bengal Engineers in 1781. He retired as a Captain in 1806.

[2] *British Government in India*, by the Marquis Curzon of Kedleston (1925), Vol. I, p. 40.

the Silver and the Copper," wrote H. E. A. Cotton in 1907,[1] "the former being much the larger and finer building. It was designed and constructed by Captain W. N. Forbes, B.E., and took six years to build. It was erected on alluvial soil reclaimed from the river, the foundations being laid at an average depth of 25 feet below the level of Clive Street, so that there is as much brickwork below as above the surface. The architecture is Grecian Doric, and the central portico facing the Strand Road is a copy in half-size of the Temple of Minerva at Athens. This Mint was opened in 1831. In the bullion-room is a fine marble bust of Major-General Forbes, who constructed the Mint and presided over it for many years. The Copper Mint, opened in 1865, consists of a very large block of buildings to the north-east of the Silver Mint."

A few years after the completion of the Silver Mint, Forbes was contemplating a still more ambitious scheme—the design of St. Paul's Cathedral in Calcutta. He set to work in 1838 and planned a structure, in a species of Gothic style adapted to local conditions, the main body of which was to be 247 feet long and 81 feet wide, with a tower, surmounted by a spire, rising to a height of 201 feet. Spacious transepts were included, and the roof was to be supported on iron trusses adorned with Gothic tracery. The design met with approval and work began in October, 1839, being completed in October, 1847, at a cost of about five lakhs of rupees, raised chiefly by public subscription. By these two successes, Forbes earned his reputation as one of the best architects of his day, belying the once popular idea that a soldier can think only of barracks and cook-houses.

With these few examples of construction in Bengal, we proceed towards the more recently occupied areas of the north and north-west in which so many military engineers have built barracks and cantonments, and so few, in recent years, have erected civil buildings of any great size. The traveller from Calcutta to Peshawar will notice a peculiar change after he has entered the Punjab, a change which is accentuated when he comes to the North-West Frontier Province. He leaves a peaceful land, devoted to commerce and agriculture, and penetrates into a region which is placid on the surface but prepared for war. Its great bridges are defended, its cantonments have strong garrisons, British troops are plentiful, each village is a miniature fortress, the inhabitants are virile, strong and martial. This is a stern country, fruitful and prosperous under British rule, but by nature hard, bleak, rigorous. In such surroundings, the activities of the military engineer must necessarily tend chiefly towards the care of troops; and the cantonments which cluster below the trans-frontier mountains, or are perched on their barren plateaux, are evidence of what he has accomplished in this

[1] *Calcutta, Old and New*, by H. E. A. Cotton, p. 914.

direction. But when the Punjab was annexed after the Sikh Wars, Colonel Robert Napier, and other Bengal Engineers, had to bear the full burden of both military and civil construction in that province; and in still earlier days, a like demand was made on the military engineers in the area now called the United Provinces. Thus the country overshadowed by the line of the Himalayas is dotted with old civil buildings erected by soldiers—offices, churches, and residences—a few of which may be mentioned here as typical of the remainder. The history of the military cantonments of Northern India cannot be included in these pages. Barracks, married quarters, magazines and cook-houses for the defenders of our Indian possessions have cost a vast sum of money, and are naturally a source of pride and satisfaction to their designers and builders, but they are not inspiring. The cantonments of India must be taken on trust: they are well planned, clean and comfortable, and they house contented men, women and children. We are concerned here with civil buildings alone.

Forty years ago, the everyday life of a military engineer in the Buildings and Roads Branch of the Public Works Department in Northern India was full of interest. Often he was stationed in some large city, possibly the headquarters of Government, where extensive works were in progress; and in his spare time he could play polo, tennis or racquets, or could get excellent sport within a few miles of his bungalow. But this was not always so. Sometimes he had no society other than that of his Indian subordinates, and was then obliged to arrange his own diversions and extract what humour he could from casual events. The humour was there, however, as the following tale by Captain G. P. Campbell, R.E., will show:—[1]" At a dreary place called Kalabagh on the Indus, having no one else to talk to but a native overseer, I gave him this problem. " What length of rope should be given to a cow tethered on the circumference of a field 500 feet in diameter to enable her to graze half the field?" The overseer said he would confer with his friend the native postmaster, who was good at "arithmetic." Some time later, I asked the result. " Sahib," said he, " the postmaster and I sat up all night trying to find out about that cow; but now we have decided it would be best to tie the cow somewhere else."

The tedium of officework during the hot weather is sometimes relieved by the quaint sayings of native clerks. It is true that most "*babu*-isms" run on the same lines, but the following conversation between an R.E. officer and his clerk, as related to the author, has its points:—

(Enter *babu* with papers for married officer newly returned from the hills.)

[1] Article entitled "The Eastern Mind," by Capt. G. P. Campbell, R.E., appearing in *The R.E. Journal*, Vol. 30, 1900, p. 257.

"Good morning, your honour. I hope you have enjoyed leave?"

"Yes, thank you, *babu*."

"And how is darling?"

(*Stiffly*) "If you mean my Memsahib, *babu*, she is very well."

"And little spring-off is well also, no doubt?"

"He is quite fit, thank you, *babu*. But look here. Why were you late for office this morning?"

"Your honour, I am very sorry."

"Well, don't be late again."

"Certainly, your honour, that is my intention. Usually, as your honour knows well, I observe the punctuality of a tick. But, your honour permitting, I wish to make petition."

"What is that?"

"Your honour, I desire transfer to other station."

"Why?"

"Sir, I am very homesick."

"But don't you live here? Isn't this your home?"

"Yes, your honour, this is my home, and I am sick of it."

With such occasional interludes, the long hours under the whirling fan or swaying *punkah* lose some of their monotony.

Nestling amid shady trees in most small stations in Northern India you will find a church, sometimes built by missionaries, but as often as not the work of a military engineer. Of these little buildings, perhaps the Church of St. John the Baptist at Roorkee is better known to Sappers than any other, and curiously enough it was designed and erected by an infantry officer though located at the headquarters of the Bengal Sappers and Miners. Its architect and builder was Lieutenant George Price, of the 1st Bengal Fusiliers, who was responsible also for the grander edifice nearby, the Thomason Civil Engineering College.[1] Price was one of those infantrymen who were trained in engineering after joining the Indian Army, and he had been employed as an Assistant Engineer on the Ganges Canal works. Subscriptions were invited towards the expense of building the church, and, Government having assisted with a small grant, it was erected before the Indian Mutiny at a cost of about £2,300. It has no tower nor steeple, and consists merely of a nave and chancel, without transept, aisles or verandahs, one entrance being in the south side, where there is a porch, and the other in the west end. Wooden trusses support a slate roof at a steep pitch. The design is Early English, simple, well proportioned and accurate in all essential details, and the building can seat 200 people. Over the altar is a window of stained glass, the gift of Colonel Sir Proby Cautley. The Bengal Sappers and Miners have always been proud of this little building, in which are many memorial tablets to their officers. It is not so picturesque as, for instance, the church of the Corps of

[1] Described later in this volume under the head of "Engineering Education."

C.M.A.'S OFFICE, MEERUT, 1925-6, OLD BENGAL ARTILLERY MESS REBUILT.

Originally designed by Captain G. F. Atkinson, Bengal Engineers (the author of *Curry and Rice*).

Guides at Mardan[1] below the Malakand Pass, which might have come straight from any English village, but it is intimately associated with the Corps at Roorkee.

St. Mary Magdalene's Church in Lahore Cantonment (Mian Mir) may be cited as an example of ecclesiastical design in the Punjab. This church was planned and built in Early English style in 1854-56 at a cost of 90,000 rupees by Major J. N. Sharp, B.E., who died at Lahore soon afterwards. It is of brick, plastered outside and inside, with wooden trusses supporting a slate-covered roof, and will accommodate 700 persons. With its marble floor and font, and stained-glass windows, the interior is most impressive. In Allahabad, in the United Provinces, is a Presbyterian church designed by Captain (afterwards Lieut.-General) F. W. Peile, B.E., and built by Lieutenant (afterwards Major-General) D. Limond, of the same Corps. This also is in Early English style. Gothic arches divide the nave from the aisles, and the floor is paved with stone flags, alternately red and white. The site of the massacre of British women and children at Cawnpore during the Indian Mutiny is marked by a memorial consisting of a Gothic screen of carved stone surrounding the well into which the bodies of the victims were thrown. The well itself is surmounted by the statue of an angel, the work of Baron Marochetti and the gift of Lord Canning, but it may not be generally known that the screen was designed by Colonel Henry Yule, late of the Bengal Engineers. At Meerut, the old Bengal Artillery Mess (now the office of the Controller of Military Accounts) was erected by Captain G. F. Atkinson, B.E., the author of *Curry and Rice,* being taken into use shortly before the Bengal Artillery was absorbed into the Royal Regiment in 1862. Its imposing appearance is indicated by the illustration of the building after reconstruction by the late Lieut.- Colonel P. H. Kealy, R.E., in 1926. These few examples of architectural work, taken haphazard from many, will suffice to show that the military engineers of the last century in India left their imprint on the country.

The ability to appreciate good architecture seems to be as much a matter of nature as of education, and the British engineer in the *mofussil* who aspires to be an architect, and hopes to induce his Indian subordinates to follow in his footsteps, may sometimes receive a shock. Another experience of Captain G. P. Campbell, R.E., provides an illustration :—" One day, to enlighten the ideas of a native subordinate who had spent 30 years of his life in making and mending barracks, I showed him some excellent photographs of Howard Castle and drew his attention to the superb fireplaces and mantelpieces, so unlike the usual ' straight-edge ' pattern of an Indian house. I remarked on the contrast between the Howard Castle

[1] The Mardan Church was designed and built by Captain H. E. S. Abbott, R.E., from a sketch design by a London architect. Abbott also designed and built the " Guides' Memorial " at Mardan.

parqueterie and the rammed mud floors of the Punjab. I exhibited carefully the glories of the marble staircases, of the princely halls, of the Corinthian columns, painted ceilings, tapestried walls, groined roofs, cathedral-like windows, lordly entrances and so forth. But he stared stolidly at all the pictures, and his only remark was, 'Sahib, of that house, *what is cost of annual repairs?*' "

One British architect in India, the late Colonel Sir Samuel Swinton Jacob, K.C.I.E., stands out as the leading military exponent of his profession on account of his exceptional originality and skill. Entering the Bombay Artillery from Addiscombe in 1858 at the age of 17 years, Jacob joined the Public Works Department as an Assistant Engineer in 1862 and served in it for no less than 34 years. He designed a host of buildings, and developed what is known as the Indo-Saracenic style of architecture, a blend of Hindu and Muhammadan ideas adapted to modern requirements. Some of his designs were severely criticized, but it cannot be denied that most of his creations are striking and beautiful. They are to be found chiefly in Central India. Among them are the Daly College and a hospital at Indore, the Albert Hall and a church at Jaipur, a college in Bhopal, public offices in Jodhpur and Dholpur, a church at Ajmer, and palaces in Bikaner and Kotah. In British India, Swinton was responsible for the designs of the Sandeman Memorial Hall at Quetta, the Victoria Memorial Hall at Peshawar, the Government of India Secretariat Offices at Simla, St. Stephen's College at Delhi, several large buildings in Lucknow, the Bank of Madras in Madras, and many fountains, canopies, altars, fonts and pulpits in gardens, public places and churches. When he died in November, 1917, at the age of 76 years, he had designed more buildings for India than any other British architect, and, in Rajputana in particular, he left behind him a great reputation.

On April 4th, 1905, a terrible earthquake occurred in the region of the Kangra Valley and Dharmsala, about 100 miles north-west of Simla. Hundreds of soldiers, and thousands of villagers, perished beneath the ruins of barracks and houses. Immediate steps were taken to provide temporary buildings for the survivors, and this work was completed in less than a year; but the reconstruction of the permanent buildings was spread over a period of at least eight years. Colonel Holme writes:—[1] " I was ordered to Dharmsala to take the place of the Executive Engineer, Mr. Farley, who had been killed. The cantonment and civil station of Dharmsala, the town of Kangra, and all the villages in the central portion of the district had been utterly destroyed. In the scheme of restoration work, the Kangra Division was divided into three portions; Captain A. A. Crookshank, R.E., had charge of Kulu, while a civilian engineer and

[1] Extracts from notes, dated March 26th, 1933, given to the author by Lieut.-Colonel A. S. Holme, O.B.E., R.E. (retd.).

I shared the remainder of the district. We were kept busy for several months in repairing roads and bridges and erecting temporary buildings for civil offices, hospitals, etc. Early in 1907 I found myself again in the Kangra Valley, where I spent the next four years rebuilding the civil station of Dharmsala on earthquake-proof lines. Lieutenant (now Colonel) W. Garforth, R.E., assisted me during the greater part of this time, and took over charge from me when I left in 1911. There was a controversy about the site of the new civil station, as some people wished that it should be rebuilt near the cantonment in Upper Dharmsala; others preferred Lower Dharmsala; but eventually the Lieutenant-Governor decided on the lower station." The disaster in the Kangra Valley is an example of the sudden emergencies which have to be met by engineers in civil employment. India is built on a grand scale, and its catastrophes are correspondingly awful; but happily it has men who are equal to the demands made upon them.

No account of the work of military engineers in the Buildings and Roads Branch of the Public Works Department in Northern India would be complete without some mention of the achievements in design and construction of Major-General Sir Sydney Crookshank, K.C.M.G., C.B., C.I.E., D.S.O., M.V.O. As a subaltern in 1898, Crookshank became District Engineer of the hill-station of Naini Tal, and there he completed the building of the stately palace known as Government House, and had unique experience in making hill-roads and dealing with the landslips which so often destroy them. He also built an Imperial Bacteriological Laboratory in a remote and densely-wooded spot in the mountains of Maktesar near Bhim Tal. But the best examples of his work are to be found in Lucknow, where he was an Executive Engineer between 1908 and 1910, when Mr. C. E. V. Goument was Chief Engineer. At that time, the Indo-Saracenic style of architecture, favoured by Sir Swinton Jacob, was sweeping over the United Provinces, and Lucknow came in for its full share. The designs were submitted to Sir Swinton for approval and possible elaboration; but they were prepared originally by Captain Crookshank, who consequently deserves much of the credit for the beauty and excellence of the buildings which resulted from them. In Lucknow, Crookshank planned and constructed King George's Medical College and Hospital, the Canning College, the Technical School, the School of Design, the Arabic College, the Post Office, the Balrampur Hospital, two bridges over the Gumti, and many minor buildings, being assisted in the first two works by Lieutenant (now Colonel) J. A. Graeme, R.E.

From Lucknow, Crookshank passed to Delhi where, as Superintendent of Works, he had charge of all the building and road-construction for the Imperial Durbar of 1911, including the preparation

of the great amphitheatre, with its shamiana, throne pavilion and stands for spectators, a triumphal arch, a market, a hospital, offices and other buildings, and review and polo grounds. The amphitheatre alone cost nearly six lakhs of rupees.[1] Before the Great War, he was engaged as a Superintending Engineer in the preliminaries connected with Lord Hardinge's vast scheme for an Imperial Capital at New Delhi, and acted for a time as Chief Engineer until Mr. (now Sir Hugh) Keeling was appointed to that post in 1912 ;[2] and after the Great War, in which he became Director-General of Transportation of the British Armies in France, he served, as Secretary to the Government of India in the Public Works Department, on the Imperial Delhi Committee, which advised on all estimates and designs and formed a connecting link between the Government engineers and the two eminent architects who designed the wonderful structures which now adorn the capital. Of these, the gigantic Secretariat and the circular Council Chamber at Raisina are the work of Sir Herbert Baker, K.C.I.E.,[3] and Government House, that of Sir Edwin Lutyens, K.C.I.E.[4] Among the few R.E. officers who worked for a time on the New Delhi scheme were Captains (now Colonels) W. H. Roberts and G. E. Sopwith, the former as Personal Assistant to Keeling, and the latter under Mr. (now Sir Thomas) Ward, C.I.E., M.V.O., the irrigation expert who advised on the scheme almost from its inception. Lieutenant R. G. G. Robson, R.E., a gallant youngster who was killed in France,[5] also worked at New Delhi before the Great War, and the construction of the New Delhi Cantonment was carried out chiefly by Major G. H. Griffith, R.E.

The Buildings and Roads Branch of the Public Works Department, except in the North-West, has seen almost the last of its Royal Engineers. Lieut.-Colonel W. de H. Haig, D.S.O., R.E., Deputy Chief Engineer in Lucknow, is in India ; but no others remain, outside the North-West Frontier Province, to represent the Corps. The designs prepared by the Department, and the structures which it has built, have often been the subject of adverse comment. Indeed, some people have been unkind enough to say that the work of the Department is all that building should *not* be. In reply, its officers need only point to New Delhi and Lucknow. Mistakes there may be, but

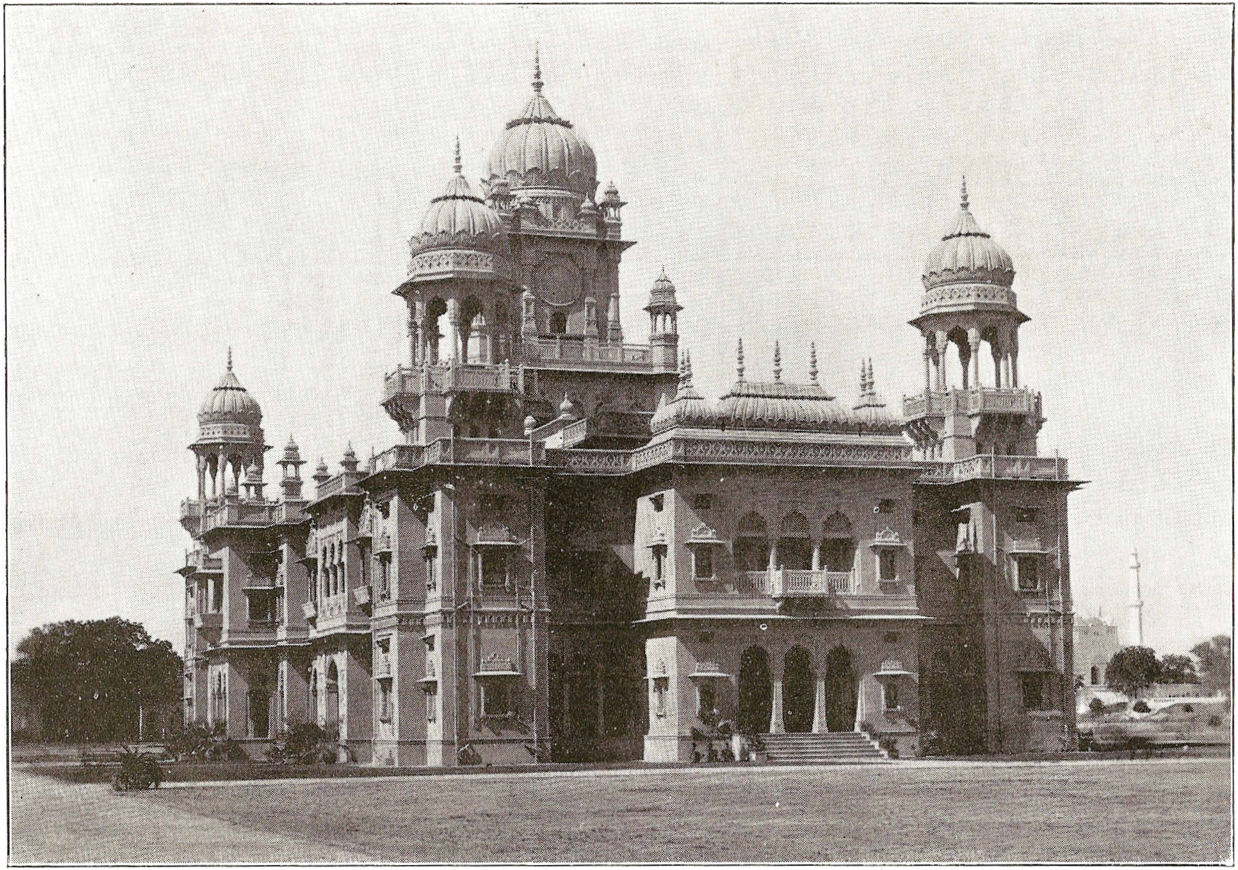
[1] " Completion and General Reports on Durbar Works, P.W.D., Delhi, 1911," by Major S. D'A. Crookshank, C.I.E., M.V.O., R.E., appearing in *The R.E. Journal*, Vol. XIX, January–June, 1914, p. 366.

[2] Sir Hugh Keeling was succeeded in 1925 by Mr. (now Sir Alexander) Rouse.

[3] Sir Herbert Baker is celebrated also for his buildings in South Africa, such as the Government Buildings at Pretoria, the Rhodes Memorial on Table Mountain, and cathedrals at Capetown, Pretoria and Salisbury (S.A.). He designed India House, and South Africa House, in London.

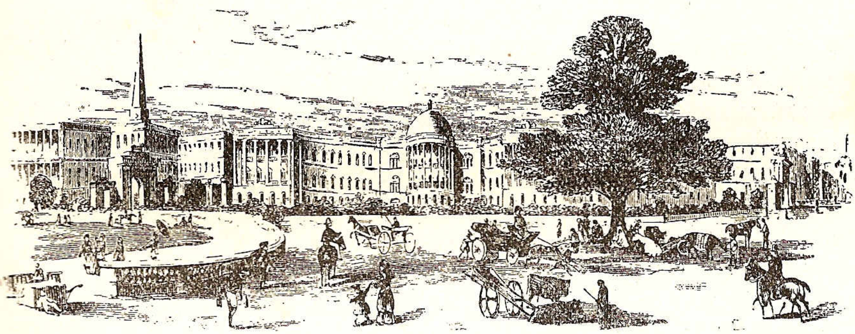
[4] Sir Edwin Lutyens designed the Cenotaph in Whitehall, the British School of Art in Rome, the British Pavilion in Paris (1900), and the new British Embassy in Washington.

[5] See Vol. I, Chapter XXIII.



KING GEORGE'S MEDICAL COLLEGE, LUCKNOW. MAIN BUILDING. SOUTH-EAST VIEW.

they are overshadowed by the general grandeur of the designs. It is true that the plans for the magnificent buildings in the capital of India and the capital of the United Provinces were originated and supervised by expert architects; but the construction was carried out by the Public Works Department, and in that herculean labour a few Royal Engineers were privileged to take their share.



GOVERNMENT HOUSE AND TREASURY, CALCUTTA, FROM THE OLD COURSE. DESIGNED BY CAPTAIN CHARLES WYATT, B.E.

CHAPTER VII.

EARLY INDIAN RAILWAYS.

IN modern India the tourist is carried swiftly and smoothly across undulating plains, over wide rivers, through dense jungles and sombre defiles, and up the sides of mountains. He lounges at full length in a luxurious railway carriage or dines in an up-to-date restaurant car. The changes of scenery, the people, and the heroine of his novel engross him, and often he hardly gives a thought to the stupendous labour which has secured him such ease and comfort. Yet every furlong, on some stretches of the Indian railways, is a monument of strenuous endeavour : over others, heat and sickness have been equally formidable. These railways have taken a heavy toll of lives, both British and Indian.

In 1849 there was not a mile of line between the Himalayas and Cape Comorin : in 1929 there were 41,000 miles, representing a capital value of some 687 millions sterling, serving every district in the country, and carrying more than 620 millions of passengers and nearly 90 million tons of goods every year.[1] The credit for this remarkable achievement should be given, not only to the engineers who built the lines, but to the three Viceroys to whom the railways owe so much—Lord Dalhousie, under whom the first railways were started, Lord Curzon, who developed the commercial side and established the Railway Board, and Lord Reading, who saved the railways from financial catastrophe after the Great War. When railways for India were first proposed by Sir Macdonald Stephenson, the founder of the Bengal system, Mr. John Chapman, the founder of the Bombay system, and Mr. J. M. Heath, the originator of the Madras system, it was asserted on all sides that the lines would obtain no traffic and that they could not compete either with roads or rivers. Colonel Arthur Cotton, M.E., the irrigation expert of Southern India, advocated a wholesale extension of canals in place of railways, which he considered outrageously expensive. But the railway engineers won their fight, and the result has been an expansion of trade, an ease of administration, a freedom from famine and a strengthening of the British military position which the early objectors failed to foresee.

In comparison with roads and canals, the Indian railways are a modern innovation, and consequently, except on the North-West

[1] "Indian Railway Development," by Sir Clement Hindley, K.C.I.E., appearing in the *Journal of the East India Association*, October, 1929, p. 196.

Frontier, their construction has rested more in the hands of civil than military engineers. The Public Works Department was formed soon after railways were contemplated, and it was only natural that civilian engineers, possibly with some railway experience, should be employed to build the Indian lines, especially as the early construction was in the hands of companies, though supervised by Government. For many years, the part usually played by the military engineer in railway employment was that of an adviser in the interest of Government, except in those turbulent or undeveloped areas, such as the Punjab and beyond the Indus, where railways had a marked strategic role. The greatest credit is due to the pioneers of railway construction in India for their achievements in surveying and building the first lines in a country in which the people and conditions were so strange to them. Their methods of surveying were crude ; yet it would be difficult to better the routes which they chose or to find serious technical faults in their alignments. While it is true that they could not go far wrong in a virgin country so long as they took their lines to the principal cities, leaving the intermediate stations to develop traffic, their planning of difficult sections, such as the ascents of the Western Ghats, showed surprising skill. Indeed, it was not till about 70 years later that any alterations were made in the Thal and Bhor Ghat lines, those wonderful examples of survey, design and construction near Bombay in which soldiers had no small share.

Taken as a whole, the military engineers in railway employment in India have been more prominent in administration and management than in construction. Although they have produced many brilliant constructors, such as those who designed and built the Khaibar Railway, the Sind–Pishin and Bolan Railways and other exceptionally difficult lines, they have aspired chiefly to become Agents or Managers, a very natural ambition in view of the pay and status of such posts and the prospects which they hold out of further employment after retirement. In the early days, the average Royal Engineer wielded a more facile pen than his civilian contemporary. His training had taught him the use of those well-turned phrases with which Victorian official correspondence was interlarded, and naturally this gift was appreciated by Government and sometimes led to rapid advancement.[1] But it should not be thought that he was, or ever became, a mere " office-wallah." He was constantly on the works and gathering technical knowledge. He had not the initial advantage of the railway training and experience which some of the civilian engineers possessed ; but his courses at Woolwich and Chatham had given him a wide outlook and the ability to learn

[1] This faculty was so highly valued that it is said that a General Manager of the N.W. Railway in India, when told that a young R.E. officer had failed in his professional (railway) examination, remarked, " You astonish me ! He has got the regular Secretariat style."

rapidly, and he soon found ample opportunities to show his ingenuity and resource in the novel problems presented by railway engineering in India. It says much for the tact of both the civil and military engineers that as a rule they worked in perfect harmony in the great task of spreading railways over the country. There were, as there always are, difficult men and cranks ; but on the whole, and in spite of the fact that the Royal Engineer held a privileged position which he no longer occupies, there was little friction between the civil and military elements of the railway services.

The first railway in England, from Stockton to Darlington, was opened for colliery traffic in 1825, and the Liverpool–Manchester line, for passenger and goods traffic, in 1830.[1] It is said that, two years later, the possibility of building a line in India, from Madras to Bangalore, was considered and that some surveying was done,[2] but nothing seems to have come of it. Curiously enough, the pioneer of railway construction in India was a military engineer who became an opponent of any great extension of railways in that country, for, about the year 1838, Captain Arthur Cotton, M.E., laid a few miles of line from Madras City towards the Red Hills for the transport of road material. Circumstances, however, prevented the completion of the Red Hills line,[3] which can hardly be considered as the true beginning of railways in India, as it was not intended for passenger or goods traffic. But railway engineers in England soon began to turn their thoughts eastwards, and it is said that in 1841 Mr. Macdonald Stephenson projected a railway in India, though he made no definite proposals until the end of 1844. In the preceding year, a railway engineer, Mr. G. T. Clerk, had gone to Bombay to study the possibilities of railway communication between that port and the interior, and, with remarkable sagacity, had proposed the construction of a line bifurcating at Kalyan so that its branches could surmount the barrier of the Western Ghats through the Thal and Bhor (Bor) Ghats. In England, Mr. John Chapman was planning a vast scheme for a Great Indian Railway, and in general it may be said that considerable attention was being focussed on India.

At length, in a despatch dated May 7th, 1845, the Court of Directors of the East India Company admitted the desirability of railways for India, and sent an expert in the person of Mr. F. W. Simms to investigate the question. Simms worked in collaboration with Captain A. H. E. Boileau and Lieutenant J. R. Western, of the Bengal Engineers, who were chosen by the Government of India. This small committee reported on March 13th, 1846, that railways could easily be made and maintained in India, that they should be intro-

[1] The first steam locomotive was built by Cugnot in France in 1769, and the first locomotive to run on rails (flat) was produced by Trevithick in Wales in 1802. George Stephenson evolved his " Rocket " between 1815 and 1825.

[2] *Indian Railways*, by Sir W. P. Andrew, C.I.E. (4th edition), Preface, p. xvi.

[3] *General Sir Arthur Cotton, R.E., K.C.S.I.*, by Lady Hope, p. 67.

THE BHOR GHAT.

A view of the Ghats. The railway traverses the distant hillside. The high tableland of the Deccan falls abruptly 60 miles from Bombay to the maritime plain.

duced by private companies, and that a line should be constructed from Calcutta to Mirzapur and thence to Delhi, with branches extending to Rajmahal, Dinapore, Rajghat, Farrukhabad, Aligarh and Meerut, and onwards through Karnal towards Simla. They thought that £15,000 a mile might cover the initial cost of construction. As Lieut.-Colonel (afterwards Major-General) W. N. Forbes, B.E., then the leading architect of Calcutta, concurred with the report, the Government of India recommended that the Calcutta–Delhi line should be constructed, and the Directors agreed with this recommendation. There followed a delay of nearly three years, but at last, on August 17th, 1849, agreements were signed with the East Indian Railway Company for a line from Calcutta to Raniganj (120 miles), with the Great Indian Peninsula Railway Company for a line from Bombay to Kalyan (33 miles), and with the Madras Railway Company for a line from Madras to Arkonam (39 miles). Work was started on the Bombay–Kalyan line in February, 1851, and this may be considered as the true beginning of railways in India. The line was opened to Kalyan on May 1st, 1854, the first 20 miles to Thana (Tannah) having been taken into use a year earlier.[1]

The difficulties of transport, before railways appeared, were indeed formidable. Sir William Andrew writes:—[2] "In 1846, when the Government of India, in spite of many prophecies of failure, were about to commence to construct railways, I ventured to mention that railways would more than double the effective strength of the army of occupation. I said that in the annual relief, infantry regiments were moved from one end of India to the other at the rate of 10½ miles a day, with six days' halt in a month. It took six weeks to travel at this rate from Calcutta to Benares.[3] In 1845, when the First Sikh War broke out, all officers, whose regiments were in the field, were ordered to join the army. About 100 engineer, cavalry and infantry officers were required to go from Calcutta to the north-west frontier of India.[4] They were sent at the public expense, and with the greatest despatch, but the Postmaster-General could only send three daily! As the journey took 16 days, travelling day and night, few of these officers rejoined their regiments before the war

[1] John B. Ireland, writing on January 8th, 1853, in his *Wall Street to Cashmere*, says (p. 135), "Returning from Malabar Hill we passed near the railway which has been constructed to run to Calcutta. About 40 miles are completed, but I think it is a great mistake to make it so solid."

[2] *Indian Railways*, by Sir W. P. Andrew, C.I.E., 4th edition (1884), Preface, p. xvii.

[3] Travelling by *dak* (horse-drawn carriage) a European could cover this distance of 428 miles in five days, exclusive of halts, and at a cost of about £25. If he preferred a *palkee* with eight bearers, the cost would be £15, but he would be nearly a month on the road. Many officers accomplished the journey on horseback in 16 days.

[4] The frontier was then on the River Sutlej. Normally, the journey from Calcutta to the Sutlej occupied more than four months.

was over. On June 18th, 1830, Sir Henry Durand, then a young officer in the Engineers, was ordered to proceed from Calcutta to Cawnpore. He started three days later, but did not reach his destination until September 7th." Such a state of affairs could not be allowed to endure. India was bound to get her railways, at whatever cost.

A prominent figure in the early history of the Bombay lines is Lieut.-Colonel John Pitt Kennedy, who transferred from the Royal Engineers to the Infantry as a subaltern in 1826.[1] In some ways, John Kennedy resembled Arthur Cotton, the champion of canals. He had boundless self-confidence, his promises were alluring, and his views so forcibly stated that they always commanded attention. Like Cotton, his imagination blinded him to hard financial facts, and his schemes were sometimes based on incorrect assumptions; but his enthusiasm made such an impression in England and India that it certainly helped the cause of railways in the East. On September 14th, 1852, Kennedy addressed a memoradum to the Directors on a general system of railways for India, arguing that his proposals would allow of such a reduction in the strength of the Indian Army that the annual financial saving in Bengal alone would exceed £1,200,000. His system, said he, would enable the East India Company to raise enough capital to build 8,322 miles of railway in Bengal, at £5,000 per mile, and proportionate distances in Bombay and Madras.

Unfortunately, Kennedy based his plans on two erroneous suppositions; firstly, that to give the best financial results, railways should run almost on a dead level, and consequently, in Western India, along the coast; and secondly, that the directions of large rivers always determine the chief locations of the population and trade. He proposed that the construction of Indian railways should be governed by a dozen rigid rules as to gradients, curves and cost per mile. He asserted that it was unnecessary to bridge all large rivers, and he condemned, heartily and completely, all that railway engineers had accomplished in England. This bombshell exploded in due course in the offices of the Government of India.

Lord Dalhousie and his Government then called for reports from their Consulting Engineers for Railways, who were their technical advisers and exercised general control over the projects of the railway companies. At that time, these engineers were Captain J. H. G. Crawford, Bo.E., in Bombay, Captain (afterwards Major-General

[1] John Pitt Kennedy was Military Secretary to Sir Charles Napier in 1849–50, when Napier was Commander-in-Chief in India. Then he became, for a time, Consulting Engineer for Railways to the Government of India. He retired in 1852, becoming Consulting Engineer in England for the Bombay and Baroda Railway Company, and in 1853 Managing Director of that Company in India. He died in 1879. He should not be confounded with General Sir Michael Kavanagh Kennedy, K.C.S.I., late of the Bombay Engineers, who has been mentioned several times in this narrative. The latter was a subaltern when Major John Kennedy wrote his memorandum on railways.

Sir Thomas) Pears, M.E., in Madras, and Major (afterwards Major-General Sir William) Baker, B.E., in Calcutta, and they proceeded to tear Kennedy's proposals to pieces. They said that his estimates of saving in military expenditure were much exaggerated ;[1] that in Bombay and Madras no trunk lines could be made with the flat gradients on which he insisted ; and that to propose, as he had done, that no railway should be undertaken whose cost promised to exceed £5,000 a mile, was unsound.[2] Kennedy, who preferred the "easy way round," had advocated a line leading northwards from Bombay along the coast to Surat, and so up the valley of the Tapti, instead of the bolder and more direct route up the Western Ghats, and Crawford pointed out that such a line would have to cross many rivers near their mouths and latterly to traverse uninhabited forests, and that it would be in competition with sea-borne trade. In support of his proposal for the northern route, Kennedy had given estimates for the alternative of ascending the Ghats ; but these were unreliable because, as Crawford remarked, he had assumed that the Ghats had an even slope, whereas they contained a sheer precipice, and his estimate of the cost of tunnelling was most inaccurate. Pears objected to a proposal by Kennedy to link Madras with Bombay by a line running down the western coast, through a gap near Coimbatore, and thence along the Cauvery Valley,[3] and, as regards his further proposal to construct railways following the courses of the Godavari and other southern rivers, Pears remarked that these rivers were not, and never had been, arteries of commerce, and passed for long distances through almost uninhabited country.

But Kennedy's projects are interesting because they are typical of the grandiose schemes which have so often been propounded by imaginative engineers in any new field of endeavour without the collection of sufficient data. The Government had to deal also with other, and quite fantastic, suggestions. For instance, Lieut.-Colonel C. W. Grant, of the Bombay Engineers, suffering perhaps from a touch of the sun, wrote a book to prove that Indian railways should not be laid on the ground, *but suspended in the air!* Throughout their length they were to be hung from chains, so that the track would be at least eight feet above ground-level and thus safe from the attacks of animals. It seems that Grant overlooked the capabilities of elephants and tigers.

Fantastic and over-ambitious proposals, however, were forgotten when Lord Dalhousie, the Governor-General, reviewed the whole question of railway routes in a masterly Minute, dated April 20th, 1853, which is now regarded as the foundation of the Indian railway system. Dalhousie advocated, in the strongest terms, the speedy

[1] *The Railways of India*, by Capt. E. Davidson, R.E. (1868), p. 79.
[2] The guaranteed lines on the 5′ 6″ gauge actually cost about £17,000 a mile.
[3] It has not yet been possible to build such a line.

and general introduction of railways, particularly between the chief cities. He objected to Kennedy's rigid restrictions as to gradients and cost per mile, and he specially recommended that a system of trunk lines should be formed to connect the Presidencies and to link the interior of each Presidency with its port. The lines were to be from Calcutta to Lahore, from Bombay to some point in Hindustan or alternatively a line by the Narbada Valley to join the proposed Calcutta-Lahore line, and a line from Madras westwards to the Malabar Coast. The Court accepted his proposals with little modification, and by the end of 1859, eight companies[1] had been formed for the construction of nearly 5,000 miles of line, with a capital, under guarantee, of £52,500,000.

Although this narrative avoids as far as possible the intricate details of finance which determine so largely the gauge, construction and administration of railways, it is necessary to mention here that the main principle in the formation of the early railway companies was a Government guarantee on their capital, without which investors would not come forward. The guarantee was 5%, coupled with the free grant of all the land required, and in return the companies had to share their surplus profits with Government after the guaranteed interest had been met. It was agreed that the railways should be sold to Government on fixed terms at the end of a certain period (usually 25 years), and meanwhile their working and expenditure were subject to general control exercised through the Government's Consulting Engineers. The scheme appeared sound, but unfortunately the early railways failed to make profits sufficient to meet even the guaranteed interest, so in 1871 the Government began to build lines by direct State Agency, the metre gauge, of which General Sir Richard Strachey was a strong advocate, being adopted for cheapness instead of the original 5′ 6″ or standard gauge. However, in spite of a bad financial position, the main object had then been attained. The country had been opened up and developed as quickly as possible.

Four State railways[2] began to operate between 1873 and 1879. From 1873 to 1878 the State railways were under Lieut.-Colonel E. C. S. (afterwards General Sir Edward) Williams, R. (B.) E., the first Director-General of Indian Railways, who held office until he was appointed, in 1880, Deputy-Director of Indian Railways at the India Office. In due course Williams became Government Director of Indian Railways in London, and received a well-earned K.C.I.E., in the same year as he became a Colonel

[1] The East Indian, the Great Indian Peninsula, the Madras, the Bombay, Baroda and Central India, the Eastern Bengal (Bengal Central), the Indian Branch (afterwards the Oudh and Rohilkhand), the Sind, Punjab and Delhi (afterwards merged in the North-Western Railway), and the Great Southern of India (now part of the South Indian Railway).

[2] The Indus Valley, the Lahore–Rawalpindi, the Rajputana–Malwa, and the Punjab Northern State Railways.

Commandant R. (B.) E. On retirement from the India Office in 1897 he became Vice-Chairman of the East Indian Railway under his old chief and close friend, Lieut.-General Sir Richard Strachey, and served on the Boards of other Indian railways, until he died in harness in October, 1907. He was associated with Sir Richard in fighting the " battle of the gauges," believing that, when rapid expansion was of paramount importance and money was scarce, narrow-gauge lines were better than no lines, but he lived to see with satisfaction the fuller protection of the North Western Frontier of India by a greatly extended scheme of standard gauge railways.[1]

In the 'eighties, five more lines[2] (known as " assisted " lines) were constructed under a partial reversion to the guarantee system, and two strategic lines were built on the North-West Frontier by purely State agency.[3] The North-Western Railway came into being in 1886 by the amalgamation of three of the four State railways completed by 1879.[4] The original guaranteed lines were then being acquired gradually by the State, and the railway systems of India were becoming very complex. It is unnecessary to trace their expansion farther. By 1871 the trunk lines aggregated more than 5,000 miles in length, and by 1890 had reached a total of over 17,000 miles. A few years hence there may be 50,000 miles of railway in India. But this huge development has been secured at a heavy cost, for it was not till 1899 that, for the first time, the Indian railways brought a net profit to the State. With these few remarks on administrative and financial matters we revert to the schemes of pre-Mutiny days, in which those Consulting, or, as some people said, " Insulting," Engineers for Railways were called upon to display so much tact in their dealings with the railway companies and such adroitness and assurance to compensate for their lack of experience.

" Rapidity in the early construction of railways in India," says G. W. MacGeorge,[5] " was hardly to be expected. Practically nothing in the way of manufactured materials or working plant was purchasable in the country, and the engineers or contractors had to manufacture, prepare or collect—often from great distances—everything required, such as bricks, stone, lime, timber, iron-work or plant of all kinds. For some time no trained subordinate staff existed, and inspectors imported from England were almost useless until they had acquired some knowledge of the language; and lastly, skilled labour of almost every description did not exist. Much delay was entailed by the natural hesitation of the chief Government

[1] A Memoir of General Sir E. C. Sparshott Williams, K.C.I.E., Col. Commandant, Royal (late Bengal) Engineers, by Colonel Sir W. S. S. Bisset, K.C.I.E., late R.E., appears in *The R.E. Journal*, Vol. VII, Jan.–June, 1908, p. 43.

[2] The Southern Maratha, the Bengal and North-Western, the Bengal–Nagpur, the Indian Midland, and the Delhi–Ambala–Kalka Railways

[3] The Sind–Pishin and Chaman Railways.

[4] Excluding the Rajputana–Malwa State Railway.

[5] *Ways and Works in India*, by G. W. MacGeorge, pp. 309, 310.

authorities amidst the conflicting views of responsible advisers, and by the opening up anew of lengthy discussions on fundamental principles, the greater number of which had already been threshed out in 20 years' experience of practical railway engineers in Europe, but which were more or less unfamiliar to many of the military engineer officers in high authority in India, who necessarily approached the subject from an almost purely theoretical standpoint."

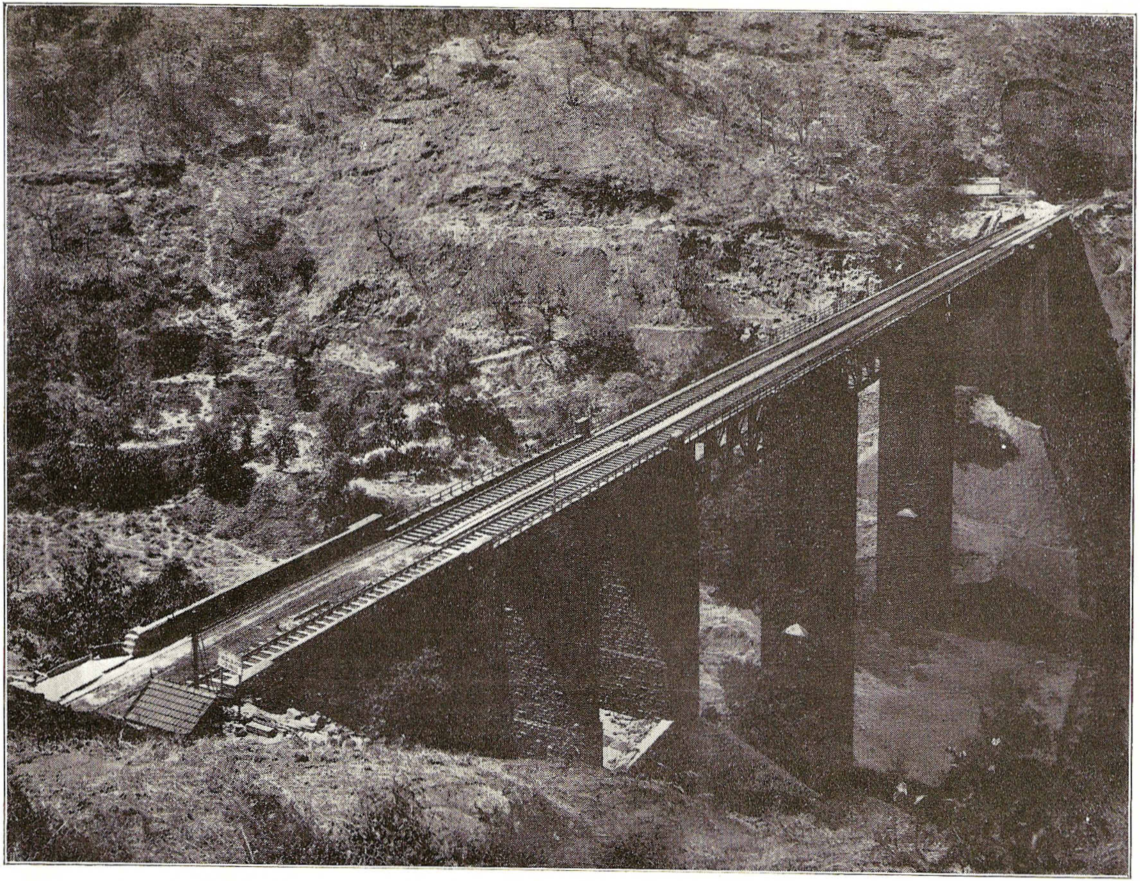
Needless to say, the pioneer railway engineers of India made many mistakes. They built too expensively for the conditions of the country and the actual work which the railways were designed to perform, and so destroyed the chance of early financial returns.[1] They concentrated too much on directness of alignment and omitted to serve many trade centres near their selected routes. They did not see that an enormous, if periodic, passenger traffic could be secured when pilgrims desired to visit sacred shrines or labourers wished to congregate on tea estates or in jute-growing areas.[2] The vagaries of Indian rivers, and the gigantic force of their floods, were not properly appreciated. Yet, with inadequate European experience and theory alone to guide them, it is remarkable what success these pioneer engineers attained under the novel conditions which they encountered.

For several years before Lord Dalhousie wrote his famous Minute in 1853, discussion had raged over the question of the best railway routes from Bombay towards the north-east and south-east. The Great Indian Peninsula Railway Company wished to connect Bombay with both Calcutta and Madras, but the Western Ghats seemed to present an insurmountable barrier. Two thousand feet in height, they run parallel to the sea and about 30 miles from it, forming, as it were, the retaining wall of the Deccan plateau. Two cart-roads alone led from Bombay to this plateau, one north-eastwards through the Thal Ghat towards Agra, and the other south-eastwards through the Bhor (or Bor) Ghat towards Poona. Both were in very poor condition ; indeed, Mr. G. T. Clerk had stated in 1847 that the Thal Ghat was unfitted for railway purposes and that the Bhor Ghat was little better. Rather than take a single line from Bombay to Kalyan with the idea of bifurcating there up the Thal and Bhor routes, Clerk advocated the construction of a single line up the Malsej Ghat between the Thal and Bhor Ghats and a bifurcation at the top. However, when it was found that one of the tunnels on the Malsej route would have to be so long that its boring would take 17 years, this route was abandoned.

Lord Dalhousie was uncertain whether the line from Bombay towards Calcutta should run, as Colonel Kennedy recommended, by

[1] *Imperial Gazetteer of India*, Vol. III, pp. 367, 383, 385.

[2] The first jute mill in India was erected at Rishra in Bengal by George Acland in 1855, and the jute industry developed with great rapidity during the next 20 years.



VIADUCT NEAR IGATPURI IN THE THAL GHAT, G.I.P. RAILWAY.
Three 140-feet girder spans and four 40-feet arches.

Surat and up the Tapti Valley to Jalgaon, or up the Thal Ghat to the same place, these being apparently the only alternatives, so he directed in 1853 that accurate surveys should be made by Kennedy along his " river-route," and by Mr. James Berkeley, Chief Engineer of the G.I.P. Railway, up the Thal Ghat, while Captain Crawford, as Consulting Engineer, reconnoitred both routes. In May, 1854, Crawford reported on Kennedy's and Berkeley's schemes in favour of the latter; but Lord Elphinstone, the Governor of Bombay, did not agree with him, and recommended to the Government of India that both lines should be made up to Jalgaon. This suggestion, however, was condemned emphatically by Lieut.-Colonel W. E. Baker B.E., Consulting Engineer to the Government of India, and by Lord Dalhousie himself, who thereupon decided in favour of the Thal Ghat scheme.[1] The Court of Directors signified their approval of the Thal Ghat route in January, 1856.

When sanction had been received, the line from Kalyan towards the foot of the Thal Ghat was pushed on rapidly, and in October, 1857, construction began on the actual incline from Kasora at the foot to Igatpuri at the head. " In a length of 9½ miles," wrote MacGeorge in 1894,[2] " there are 13 tunnels having an aggregate length of 7,956 feet, six lofty viaducts having a total length of 2,223 feet and ranging from 82 to 182 feet high, 15 bridges, and between 60 and 70 culverts."[3] One reversing station was included, but this has been abolished in recent years. Although the line from Kalyan to Kasora was opened in 1861, the Thal Ghat incline was not completed till 1865, when the trunk line had been taken through Manmad, Jalgaon and Bhusawal, with a branch from Bhusawal to Nagpur. Five years later, the G.I.P. Railway from Bombay met the East Indian Railway at Jubbulpore, thus establishing a through route between Bombay and Calcutta *via* Allahabad and Benares.

The Bhor Ghat was selected in 1853 as the route for the other trunk line of the G.I.P. Railway, which was designed to lead from Kalyan to Poona and Raichur and thus to link Bombay with the Madras railway system. This decision was only reached after an exhaustive survey of the Western Ghats for a length of about 80 miles. Captain Crawford favoured the Kasur (Kussoor) Ghat in preference to the Bhor Ghat, so in February, 1854, Lord Elphinstone directed that a careful survey should be made of the Kasur route. The result having proved that that route was impracticable, the Bombay Government definitely accepted the Bhor Ghat route in October, 1854, and ordered the completion of the lines above and below it.[4]

[1] Minute by the Governor-General, dated July 18th, 1855.

[2] *Ways and Works in India*, by G. W. MacGeorge, p. 351.

[3] Nearly two-thirds of the 9½ miles were laid on curves, the sharpest of which had a radius of only 17 chains. One tunnel, 490 yards long, was driven through the hardest basalt.

[4] *The Railways of India*, by Captain E. Davidson, R.E., p. 272.

A contractor named Faviell began the construction of the Bhor Ghat incline in January, 1856, and in June, 1858, two miles of the upper part—from Khandala to Lonavla (Lanowli)—were opened for traffic; but Faviell gave up the contract in the following March and it was re-let to Mr. S. Tredwell, who, however, died within a few days of landing in India. Wonderful to relate, the huge project was then completed by Tredwell's widow. In order to avoid serious delay, she conducted the business through the medium of her managers, Messrs. Adamson and Clowser, and employed usually about 25,000 men and in 1861 more than 42,000.[1] This is probably the only instance of an engineering work of the first magnitude being carried out in India by a woman contractor. Mrs. Tredwell knew nothing of railway engineering, but her business acumen and courage were of the highest order, and she succeeded in a great venture.

The Bhor Ghat incline, one of the engineering marvels of India, begins about 30 miles from Kalyan and ascends 1,831 feet to Lonavla in a length of under 16 miles. No less than 10½ miles of that length are curved, and the steepest gradient is about 1 in 37. "The double line of broad-gauge railway constructed up the Bhore *Ghat*," writes G. W. MacGeorge,[2] "consists of a continuous series of heavy cuttings and embankments, reaching 76 feet in depth or height, broken up by a rapid succession of tunnels pierced through projecting headlands, and by bold lofty viaducts of masonry over deep rocky ravines and gorges with which the face of the precipitous cliffs is constantly intersected. The cuttings and tunnels are, for the most part, blasted through basaltic rocks of the hardest description. The line is frequently carried clinging to steep hillsides, with the inner portion of its formation surface notched or benched into the rock whilst the outer portion is carried on an artificial bank having an enormous outward slope. The works on the Bhore *Ghat* incline comprise 25 tunnels of a total length of over 2¼ miles. Being always on steep gradients, and often on curves, the most accurate setting out was necessary. There are altogether on the *Ghat*, eight lofty viaducts of arched masonry, having a total length of over ½-mile. The two largest are 504 feet long with a maximum height of no less than 160 and 163 feet above foundations. There are 22 smaller bridges and 81 culverts. The construction of this barely 16 miles of mountain railway occupied 7¼ years and cost £1,100,000."

This brief description gives only a general idea of a magnificent achievement in railway engineering. It is true that military engineers did not carry out the work, but they were largely instrumental in the selection of the route, and they advised the contractors during

[1] *Indian Railways*, by Sir W. P. Andrew, C.I.E., Preface, p. xxxi.
[2] *Ways and Works in India*, by G. W. MacGeorge, pp. 354, 357.

the operations, and for these reasons they deserve some of the credit for the success of the undertaking. It may be added that, with the exception of the abolition of a reversing station, the Bhor Ghat incline remains to-day much as it was 70 years ago.

Many large works were designed and executed before 1870 by the civilian engineers of the G.I.P. Railway Company under the general superintendence of the military Consulting Engineers of Government —for instance, a viaduct and bridge over the Tapti River near Bhusawal on the way to Jubbulpore. This consisted of 28 masonry arches of 60-feet span and five wrought-iron girder spans of 138 feet, and its cost was £163,000. Reconstruction was necessary in later years owing to faults in the masonry piers and under-estimation of the force of the river floods, which, on the Tapti, are sometimes 70 feet deep. A more satisfactory structure was a viaduct and bridge, 350 yards long, built over the Narbada River near Jubbulpore in 1863–66 at a cost of £67,000. This had six arched openings of 40-feet width, and five wrought-iron pin-jointed deck-spans[1] of 150 feet, the bottoms of the girders being 77 feet above the riverbed. In spite of the increasing speed and weight of traffic, this structure stood until September, 1926, when it was destroyed by a flood and reconstructed as a steel bridge of six 169-feet through-spans[2] and two approach deck-spans of 45 feet length. The new bridge was opened for traffic in June, 1928. A company of Bombay Sappers and Miners assisted materially in this work by throwing a pontoon and trestle footbridge, 370 yards long, across the Narbada between October 12th and November 3rd, 1926, for the transhipment of passengers, and maintaining it for nearly six months.[3] This is one only of the many instances in which military engineers have assisted their civilian brethren in modern times.

Reverting now to more ancient days, it may be remarked that permission was given in 1855 to the Bombay and Baroda Railway Company,[4] of which Lieut.-Colonel J. P. Kennedy was the Chief Engineer, to construct a line from Surat to Ahmadabad, and Kennedy began at once on this project. He soon found, however, that Surat was unsuitable as a terminal seaport and induced the Court of Directors in 1859 to grant him permission to extend the railway from Surat southwards to Bombay. He was then confronted with the problem of bridging the swampy and tidal creeks and rivers

[1] A " deck-span " is one in which the train runs *above* the girders, the track being carried on the top booms.

[2] A " through-span " is one in which the train runs *between* the girders, the track being carried on transverse members resting on the lower booms of the girders.

[3] " The Washaway and Reconstruction of the Nerbudda Bridge on the G.I.P. Railway," by G. C. Minnitt, appearing in the *Minutes of the Proceedings of the Institution of Civil Engineers*, Vol. 232, 1930-31, Part 2, pp. 159, 160.

[4] Now the Bombay, Baroda and Central India Railway.

which lie between these coastal towns. Being an ingenious engineer he had already experimented successfully on the Surat-Ahmadabad line with special types of piers suitable for railway bridges on alluvial soils, and had also standardized his iron bridge spans with great benefit to speed and quickness of construction. So, on the section from Surat to Bombay, he rejected masonry piers and abutments in favour of screw piles[1] which he forced into riverbeds with the aid of 32 bullocks to each pile. Three such piles, screwed home, cleared of mud and filled with concrete, sufficed for each pier of his railway bridges, and on his piers he placed Warren girder spans, always 60 feet in length.

Among the most difficult bridges which Kennedy had to build were those over the Bassein Creek separating the island of Salsette from the mainland, where there were two channels to be crossed, one of which was nearly a mile wide; but he completed both bridges by 1864, the southern with 69 spans of Warren girders and the northern with 25 spans. These iron girders were replaced by steel ones of another type in 1896, and these in turn were used until January, 1927, when new plate-girder deck bridges were completed on adjacent sites and taken into use.[2] By 1866, trains were running between Bombay and Ahmadabad, and during the next 15 years the B.B. and C.I. Railway extended its mileage far into Rajputana; but the confident predictions of Kennedy that the older section from Surat to Bombay could be made cheaply proved to be incorrect, for the actual cost was more than £20,000 a mile. Nevertheless it was well for the Western Presidency that it had the services of this enthusiastic optimist, for it was due to his energy that Bombay was given an additional outlet for her trade and brought into closer touch with the hinterlands of Broach and Surat, which produced excellent cotton.

We now turn to the inception of railways in Madras, in which several military engineers took part. Unfortunately the available information is meagre, owing to the loss of the records of the old Madras Railway. It seems that a "Madras Railway Company" was formed in London as early as July, 1845, to build a line from Madras town to a trade centre called Walajanagar, better known as Arcot, lying about 70 miles to the south-west. But Mr. F. W. Simms, the railway expert, failing to foresee the distrust which might be shown by investors in England, recommended at first that Government should not guarantee any interest, or grant any free land, for railways in India,[3] and these and other stipulations killed the infant

[1] These metal piles were 2½ feet in diameter and cast in sections nine feet long which could be bolted together as required. Trouble was experienced with electrolytic corrosion of the piles in tidal water as wrought-iron bracing was used.

[2] "The Rebuilding of the Bassein Bridges on the B.B. and C.I. Railway," by B. B. Haskew, appearing in the *Minutes of the Proceedings of the Institution of Civil Engineers*, Vol. 230, 1929–30, Part 2, p. 222.

[3] *The Railways of India*, by Captain E. Davidson, R.E., pp. 327, 328.

railway company. It was not till after the report of the committee, consisting of Mr. Simms, Captain Boileau and Lieutenant Western, had been considered in 1846 that a project for a line from Madras to Walajanagar was actually prepared, presumably by military engineers, and submitted to Mr. Simms for his opinion. Then came the official sanction to the building of short "experimental" lines in Bombay and Bengal, and the subject of a railway in the Madras Presidency was revived.

Colonel (afterwards Major-General) Duncan Sim, late M.E., took up the matter in 1849, supported by the Europeans in Madras and sympathizers in London, and Captain G. C. Collyer, M.E., offered to make a survey and estimate. The result was the appointment of a small committee, including Major (afterwards Major-General Sir Thomas) Pears, and Captains J. H. Bell and G. C. Collyer, all of the Madras Engineers, to ascertain the best direction for a line and to complete the collection of all necessary information. The Directors desired to encourage the construction of a Madras railway, but the Board of Control refused permission, because they were doubtful whether Madras really needed a railway, and wished in any case to gain experience elsewhere before starting one. Long arguments followed, but the Board remained obdurate, and the question was shelved for a time. Madras is not so rich as some of the other Presidencies in valuable products such as jute and cotton.

Then came the appointment of Pears as Consulting Engineer for Railways, with instructions to report not only on a possible experimental line but on a general system of Madras railways, and this he did most ably in a series of memoranda written during 1850. Some of his conclusions may have been wrong, but he showed imagination. He said that the province should be served by two trunk lines: that one should run from Madras by Salem and Coimbatore, and thence through a gap in the Western Ghats to the small seaport of Beypore near Calicut on the Malabar Coast,[1] and that the other, diverging from the first line at a point some 70 miles from Madras, should be taken westwards to Bangalore, then northwards to Bellary, and so to Raichur, where it would meet the railway from Bombay. At the end of 1851 he asked for permission to begin to build a line at once almost due west from Madras, its subsequent course being fixed by further surveys in the Eastern Ghats, but he was against taking it to Walajanagar and some other trade centres because of the extra length and cost. In this he committed a grave error. He proposed that the line should be laid first to a small place called Menil, 50 miles from Madras, and the Government of India sanctioned this project in March, 1853.

Meanwhile it was found that trade between Madras and the interior

[1] A distance of 406 miles.

followed two general routes—one south-westwards through Coimbatore and the other north-westwards through Cuddapah. Provision had been made by Pears for the former, but not for the latter. However, as the south-westerly line towards Malabar seemed to be the more urgent demand, it was taken in hand and executed without contractors at a very reasonable cost. The river crossings are numerous, but none is difficult except the Cauvery. Work began at Madras on June 9th, 1853, and in less than three years a length of 64 miles of 5′ 6″ gauge line was opened for traffic. By 1862 the iron road stretched across the peninsula from Madras to Beypore, and by 1864 a branch was completed to Bangalore. Soon afterwards the towns of Negapatam and Trichinopoly were connected by the Great Southern of India Railway Company and the line was extended to Erode on the Madras Railway. This Company, and another called the Carnatic Company, were subsequently amalgamated into the South Indian Railway Company, which built lines from Madras *via* Cuddalore to Tanjore and from Trichinopoly by Madura to Tuticorin. In March, 1871, the north-western trunk line of the Madras Railway, running from Arkonam through Cuddapah to Raichur, was finished, and railway construction in Southern India then practically ceased for nearly ten years.

It is impossible to deny that the early history of the Madras railways contains many unfortunate decisions. As on the Trans-Siberian railway, the engineers seemed to imagine that towns would spring up like mushrooms along their lines, or even shift their positions to be near them, basing this theory on American experience and forgetting that America is a new country and India a very old one. The north-western trunk line through Cuddapah traversed an area which, for the greater part of the year, was almost a desert, and for the remainder, sparsely cultivated. It could not be expected to pay. The south-western line from Madras divided the Presidency into two nearly equal parts, the country to the north being served by the broad-gauge Madras Railway and that to the south by the metre-gauge South Indian Railway. The fields were distinct: there was no competition: the country was poor. Both railways caused heavy losses to Government, and the onus of this must rest in part on Major T. T. Pears, Captains C. C. Johnston and P. P. L. O'Connell, Lieut.-Colonel J. C. Anderson, Captain H. L. Prendergast, and Lieut.-Colonel J. H. M. S. Stewart, of the Madras Engineers, who were successive Consulting Engineers for Railways between 1850 and 1872.[1] But the fact that all these officers, except Anderson, attained the rank of Major-General before or on retirement, shows that their successes were considered to outweigh their failures. They were engaged in a great experiment in which they had no time for long deliberation.

[1] *Military History of the Madras Engineers and Pioneers*, by H. M. Vibart, Vol. I, p. 589.

While the engineers of Bombay and Madras were wrestling with their railway problems, those of Bengal were similarly employed, though confronted with fewer obstacles. The alluvial plains of the Ganges Valley allow the more general use of flat gradients. Mr. Macdonald Stephenson began to consider a scheme for a line from Calcutta towards Delhi in 1841; but it was not recognized officially until 1844, and another five years elapsed before an agreement was signed with the East Indian Railway Company,[1] whose Chief Engineer, Mr. George Turnbull, arrived in Calcutta in May, 1850, and became the prime mover in a great undertaking. The original idea was to construct a single line from Calcutta to Raniganj, a place about 120 miles from the capital and situated in the coalfields near Burdwan;[2] but as it seemed doubtful whether the inhabitants would use the railway, and whether it could be built easily and with a reasonable chance of financial gain, Lord Dalhousie sanctioned the building only of part of the line—an experimental length of 37 miles to Pandua—and work began on this in January, 1851. For reasons of economy the Calcutta terminus was located at Howrah, on the right bank of the Hugli, this spot having been selected by Mr. F. W. Simms,[3] the first Consulting Engineer to the Government of India. Simms left India soon afterwards and was succeeded by Lieut.-Colonel John Pitt Kennedy, whose later exploits on the Bombay side have already been recorded.

The Ganges flows in a great arc from Benares through Patna to the delta in which lies Calcutta, and consequently two general routes were open for a railway from Calcutta to the north-west. Either it might be taken directly across the arc, traversing rather hilly and sparsely-populated country, or it might follow the sweep of the river. True to his principles of flat gradients and small cost per mile, Kennedy strongly advocated the Ganges Valley route where the population was thickest. Under the circumstances, his choice was probably justified, although he underestimated the difficulties of bridging and the effect of the competition of river traffic. Lord Dalhousie accepted his recommendation, and thus the credit for the selection of the first route of the East Indian Railway, beyond the experimental section, belongs to a military engineer. The experimental line was opened as far as Pandua in September, 1854, and to Raniganj in February, 1855.[4]

In 1853, however, before the infant line had reached the Raniganj coalfields, Lord Dalhousie had given his conception of what the railway to the north-west should ultimately become. "The line I have sketched from Calcutta to Attock," wrote he,[5] "even though

[1] The agreement was signed on August 17th, 1849.
[2] The Burdwan coalfields were opened in 1815.
[3] The adoption of a 5′ 6″ gauge was also recommended by Simms.
[4] *The Railways of India*, by Captain E. Davidson, R.E., p. 153.
[5] Minute by the Governor-General, dated April 20th, 1853.

it should not be carried at present beyond the river Jhelum, will constitute a very noble work. . . . Whether hostilities shall come from Cabul or Nepaul, the line of railway I have referred to would be of incalculable value. Touching every important military station from Calcutta to the Sutlej, connecting every depot, Allahabad, Agra, Delhi, Ferozepore, with the arsenal in Fort William, it would enable the Government of India to assemble on either frontier an amount of men and materials of war sufficient to deal with any such emergency and within a period which would be measured by days. . . . The course which this railway would follow is at the same time the very best which it would be possible to select for the interests of trade and the local advantage of this portion of India." Thus the great proconsul of Indian railways on his most ambitious scheme.

The river route for the East Indian Railway from Burdwan had been chosen by Colonel Kennedy after careful reconnaissance of both routes in February, 1851, in company with Mr. G. Turnbull, the Chief Engineer of the railway; and when Kennedy was succeeded in March by Major (afterwards Lieut.-General Sir William) Baker, B.E., the latter continued, with Turnbull, to examine the river route as far as Rajmahal, 199 miles from Calcutta. They thought that there should be few difficulties, and sent in their proposals in 1852. Turnbull continued his reconnaissance up to Allahabad, and, after he had submitted proper surveys, a contract was signed on February 15th, 1854, for an extension from Burdwan to Delhi itself, as it was known, through surveys executed for the Ganges Canal, that there would be no serious obstacles between Allahabad and Delhi.

It would be superfluous to attempt to trace the course of the construction of the East Indian Railway, step by step. When the Indian Mutiny began, the line was open only as far as Raniganj, near Burdwan, because an exceptional number of viaducts were required to cross the drainage of the country near the Ganges, and a large bridge over the Son (Sone) River near Patna delayed the advance. If the railway had reached Allahabad before 1857 it is probable that the Mutiny would have been nipped in the bud; as it was, reinforcements from Calcutta had to travel slowly by road or river. Trains ran for the first time to Moghal Sarai, opposite Benares, in February, 1863, and did not reach Delhi, across the newly-completed Jumna Bridge, until 1866.[1]

The construction of the East Indian and other early railways in Bengal and its neighbouring provinces in the north was executed almost wholly by contractors working under the civil engineers of the railway companies. Military engineers had little part in it except in an advisory capacity on behalf of Government. Lieut.-Colonel W. E. Baker, B.E., remained as Consulting Engineer to the Govern-

[1] The approach to Delhi through Salimgarh was impossible until the Mughal King was deposed during the Mutiny. Hence the first alignment followed the right bank of the Jumna, and a bridge was needed to reach Delhi.

ment of India until November, 1857, when he was succeeded by Captain (afterwards Colonel Sir Henry) Yule, B.E., who was followed in 1862 by Lieut.-Colonel (afterwards Lieut.-General Sir Richard) Strachey, B.E. Among other Consulting Engineers for Railways to the Government of India or the northern Provincial Governments during the 'sixties and 'seventies were Lieut.-Colonels C. J. Hodgson, G. Sim, J. P. Beadle, H. Drummond, F. S. Taylor, E. C. S. Williams, J. G. Medley, and R. de Bourbel, all of the Royal (late Bengal) Engineers. Some of these made a reputation as practical engineering advisers, and all were able men, but they were rarely in charge of actual construction.

Apart from openings for natural drainage, the four principal bridges on the original line of the East Indian Railway up to Delhi were those over the Son River near Patna, the Tons (Tonse) River east of Allahabad, the Jumna at Allahabad, and the same river again at Delhi. The Son River presented a serious barrier of great width, but a bridge was begun in 1856 after Baker and Turnbull had selected a site. Then came the Mutiny, and in July, 1857, the rebels destroyed the results of much hard labour. However, a structure nearly seven-eighths of a mile in length, with 28 wrought-iron lattice-girder spans of 150 feet, was completed in 1862 at a cost of £330,000. The Tons Bridge[1] was finished in 1864, Major H. Drummond, R.E., being the Consulting Engineer, and in the following year the Jumna Bridge at Allahabad was opened after an expenditure of £445,000.[2] In 1866 the bridge over the Jumna at Delhi[3] was completed at a cost of £166,000, and so the ancient Mughal capital was linked with Calcutta. By that time a chord line from Burdwan to Luckeesarai had been sanctioned for the East Indian Railway in Bengal to shorten the route from Calcutta to the north-west. Other new lines developed rapidly. An Eastern Bengal Railway from Calcutta northwards to the Ganges was in existence,[4] and in 1874 approval was given to the building of a metre-gauge line, known as the Northern Bengal State Railway, from the north bank of the Ganges to Siliguri below Darjeeling; but such expansions of the railway systems are outside the scope of this sketch, which must be confined mainly to the work of military engineers, with occasional digressions to less technical subjects.

In 1877, when Queen Victoria was proclaimed Empress of India, the railways were still in a primitive condition and were a source of wonder to the uneducated population. For instance, many of the villagers who thronged to use this new means of locomotion were

[1] Seven spans, similar to those of the Son Bridge.

[2] Fourteen lattice-girder spans of 200 feet, and three small spans. There is now a bridge over the Ganges also at Allahabad.

[3] Twelve lattice-girder spans of 211½ feet.

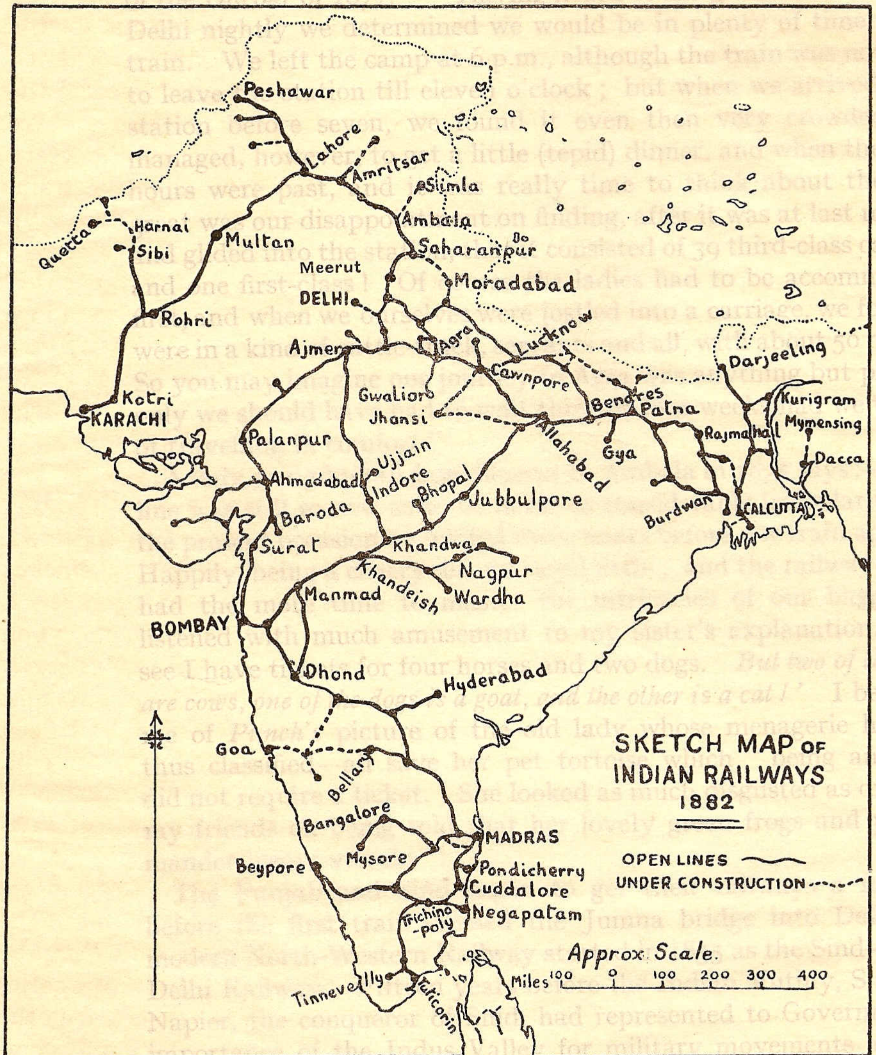
[4] The Eastern Bengal (Bengal Central) Railway to Kushtia and Damukdia was opened in 1862. The route was selected after reports had been submitted in 1855 by Lieut.-Colonel W. Abercrombie and Lieut. W. W. Greathed, B.E.

convinced that a "fire-devil" was imprisoned in the engine and bribed to do his work by a draught of cold water at every station.[1] The inconveniences of a journey by rail are thus described by a spectator of the Durbar of 1877.[2] "Having heard of the great crowds leaving Delhi nightly we determined we would be in plenty of time for the train. We left the camp at 6 p.m., although the train was not timed to leave the station till eleven o'clock; but when we arrived at the station before seven, we found it even then very crowded. We managed, however, to get a little (tepid) dinner, and when the weary hours were past, and it was really time to think about the train, great was our disappointment on finding, after it was at last made up and glided into the station, that it consisted of 39 third-class carriages and one first-class! Of course the ladies had to be accommodated first, and when we ourselves were jostled into a carriage, we found we were in a kind of cattle-truck, servants and all, with about 50 natives! So you may imagine our journey to Agra was anything but pleasant, only we should have had to wait three or four weeks had we thought of travelling in comfort."

A lady going by rail from Meerut to Ambala in 1875 says:—[3] "The line was still so new as to be liable to considerable irregularity. On the present occasion we waited three hours before our train appeared. Happily, being a cheery set, we cared little; and the railway officials had the more time to master the intricacies of our baggage. I listened with much amusement to my sister's explanation. 'You see I have tickets for four horses and two dogs. *But two of the horses are cows, one of the dogs is a goat, and the other is a cat!*' I bethought me of *Punch's* picture of the old lady whose menagerie had been thus classified—all save her pet tortoise which, 'being an insect,' did not require a ticket. She looked as much disgusted as did one of my friends on being told that her lovely green frogs and pet salamander were 'vermin'!"

The Punjab and Sind began to get their railways a few years before the first train crossed the Jumna bridge into Delhi. The modern North-Western Railway started in 1855 as the Sind–Punjab–Delhi Railway. Fifteen years before the Indian Mutiny, Sir Charles Napier, the conqueror of Sind, had represented to Government the importance of the Indus Valley for military movements and commercial traffic, and, after the inauguration of the East Indian and Great Indian Peninsula Railways in 1849, his views received new consideration. Four small companies,[4] grouped under one management in England, called the Sind and Punjab Railway Company, were entrusted with the tasks of making a railway line from Karachi

[1] *Journal of a Lady's Travels Round the World*, by F. D. Bridges, p. 196.
[2] *Chatty Letters from East and West*, by A. H. White, p. 68.
[3] *From the Hebrides to the Himalayas*, by Constance F. Gordon Cumming, Vol. II, p. 86.
[4] The Sind Railway Company, the Indus Flotilla Company, the Punjab Railway Company and the Delhi Railway Company.



SKETCH MAP OF INDIAN RAILWAYS, 1882.

to Kotri, opposite Hyderabad on the Indus, running steamboats from Kotri up to Multan, laying a line from Multan through Lahore to Amritsar, and afterwards prolonging it to Delhi—a total distance of 1,232 miles, including 570 miles by river. Work began at Karachi on April 29th, 1858, when Sir Bartle Frere, K.C.B., the Commissioner of Sind, wheeled the first barrow-load of earth,[1] and the line was opened to Kotri in 1861.

Sanction was given in 1871 and 1872 for the connection of Hyderabad with Multan by an Indus Valley State Railway, and at the same time the Punjab Northern State Railway was begun, on the metre-gauge, from Lahore towards Peshawar. In due course the Jhelum was bridged, and in 1880 the railway reached the Indus at Attock, whence trains were able to run through to Peshawar after the completion of the Attock Bridge in May, 1883. Three years later the North-Western State Railway came into existence through the amalgamation of the Sind, Punjab and Delhi Railway with the Indus Valley and Punjab Northern State Railways. Of all the railways of India, the North-Western is the one which has owed most to the work of military engineers. The defence of India depends on its efficiency. Yet for some years it was the target of critics who protested against the building of railways from borrowed capital. But the completion of the Chenab and Jhelum Canals enormously increased the grain-carrying traffic on the North-Western Railway, thus yielding a large profit for the State.

The section of the North-Western Railway stretching across the desert from Multan to Lahore is probably unique. Constructed between 1859 and 1865, it runs nearly straight for 219 miles from one city to the other, with one length of 114 miles which is absolutely straight. The steepest gradient is 1 in 600, and most of the line is almost level. Only nine small bridges were needed, six of which were built within five miles of Lahore. Amritsar was soon connected with Lahore, and the route for a railway from Amritsar to Ghaziabad near Delhi (303 miles) having been selected in 1863, the construction of this section was given out to contract in 1865 at £12,630 a mile, exclusive of rolling stock. The line cuts across the Beas, the Sutlej and other important rivers before it reaches Ambala, and crosses the Jumna not far from Saharanpur. All these formidable obstacles were spanned by wrought-iron lattice-girder structures which have been replaced in the present century by modern types. The girder spans were standardized to a length of 111½ feet, the Beas Bridge requiring 29 spans, the Sutlej Bridge at Phillour, 38 spans, and the Jumna Bridge, 24 spans. Before 1875, trains could run from Calcutta through Delhi[2] and Lahore to the Indus at Multan, and by

[1] Article entitled " The Sind Railway," appearing in *Professional Papers on Indian Engineering*, Vol. II, 1865, No. LXXXVI, p. 330.

[2] There was a " back-shunt " at Delhi, until the Delhi–Ambala–Kalka line was built.

1880, to Karachi itself. The final stages of this first expansion took place while Lieut.-Colonel J. G. Medley, R.(B.)E., was Consulting Engineer for Railways in the Punjab, and much of the credit for their success should go to him. It may be mentioned also that after the passing of an Indian Railways Act in March, 1879, a Railway Conference assembled at Calcutta in February, 1880, under Major-General J. S. Trevor, C.S.I. (late R.(Bo.)E.), to frame rules for the working of all the railways in India. The Second Afghan War was proving conclusively the paramount importance of railway communication. Co-ordination of the working of all the railway systems was essential.

No reference has been made in this chapter to the beginning of railway construction in Burma or the Native States of India. The lines in these territories are mostly on the metre-gauge[1] and were not begun for many years after railways had developed elsewhere. The first metre-gauge railway in Burma was opened in 1877, running for 161 miles from Rangoon northwards to Prome on the Irrawaddy. This was followed in 1884–85 by a line, 166 miles long, from Rangoon to Toungoo on the Sittang River, which was extended a further 220 miles to Mandalay in 1889, and still farther in more recent times. Railways were introduced gradually into the Indian States after the opening of a short length of narrow-gauge line in Baroda in 1873. Hyderabad, Mysore, Jodhpur, Bikaner and other States followed suit; but their systems cannot compare in size with the enormous network of the British railways, and few military engineers have been much concerned in their development.

This short sketch of the introduction of railways into India is an attempt to sift some of the doings of the East India Company's and Royal Engineers from the mass of statistics, and technical and financial details, which fills the pages of railway history. As a body, railway engineers seem to take life seriously, and particularly, to judge from their writings, the engineers of olden times who were oppressed by new and heavy responsibilities and the still heavier literature which they were obliged to study. The author once asked an expert to tell him some amusing stories connected with his railway work in India. The answer was, "There is nothing amusing in railways!" But even if there is little that is amusing, there is much that is interesting, and perhaps in India more than elsewhere, for in that country the early railway engineers, both civil and military, conducted one of the greatest experiments the world has yet seen, and brought it to a successful conclusion.

[1] H.E.H. the Nizam's State Railway in Hyderabad, Deccan, was made on the standard gauge. It now has a metre-gauge section in addition.

CHAPTER VIII.

RAILWAY REMINISCENCES.

THE growth of the Indian railway systems during the last half-century has had no counterpart in the world In 1881 there were approximately 9,900 miles of line; in 1891, 17,300 miles, in 1901, 25,300 miles. To-day more than 42,000 miles of line[1] traverse our eastern sub-continent and represent invested capital amounting to nearly 700 millions sterling. The most rapid construction took place between 1896 and 1900, when no less than 5,000 miles were opened, and the period of greatest stagnation was after 1913, when barely 3,000 miles were added in ten years. Then came a revival in 1923. An extended programme was resumed and maintained for several years, to be followed once more by a period of depression during the recent series of financial crises. Since the far distant days when the first train entered Peshawar, new lines have been started by Government and amalgamations have produced new concerns; but the history of these developments is so complicated that no attempt can be made to record it in these pages. Instead, it is proposed to describe some of the achievements and adventures of a few of the hundreds of Royal Engineers who have served on the Indian railways, for these have a human interest and illustrate the difficulties which have been met and overcome by soldiers and civilians working as comrades in a great adventure.

More credit, perhaps, should be given to Lieut.-General Sir Richard Strachey, G.C.S.I., F.R.S.,[2] than to any other engineer, civil or military, for the general welfare and progress of the Indian railways during the latter part of the last century. His brother, Sir John Strachey, G.C.S.I., made a still wider claim on his behalf. "In my belief," wrote he,[3] "there are few men living who have done so much for the improvement of Indian administration. It is to him that India owes the initiation of that great policy of the systematic extension of railways and canals which has been crowned with such extraordinary success, which has increased to an incalculable extent the wealth of the country and has profoundly altered its condition. To him is due the conception of those measures of financial and administrative decentralization which have had the most far-reaching

[1] Mostly of 5′ 6″ gauge, with a smaller amount of metre-gauge and very small amounts of 2′ 6″ and 2′ gauge.

[2] Sir Richard Strachey was also an LL.D.

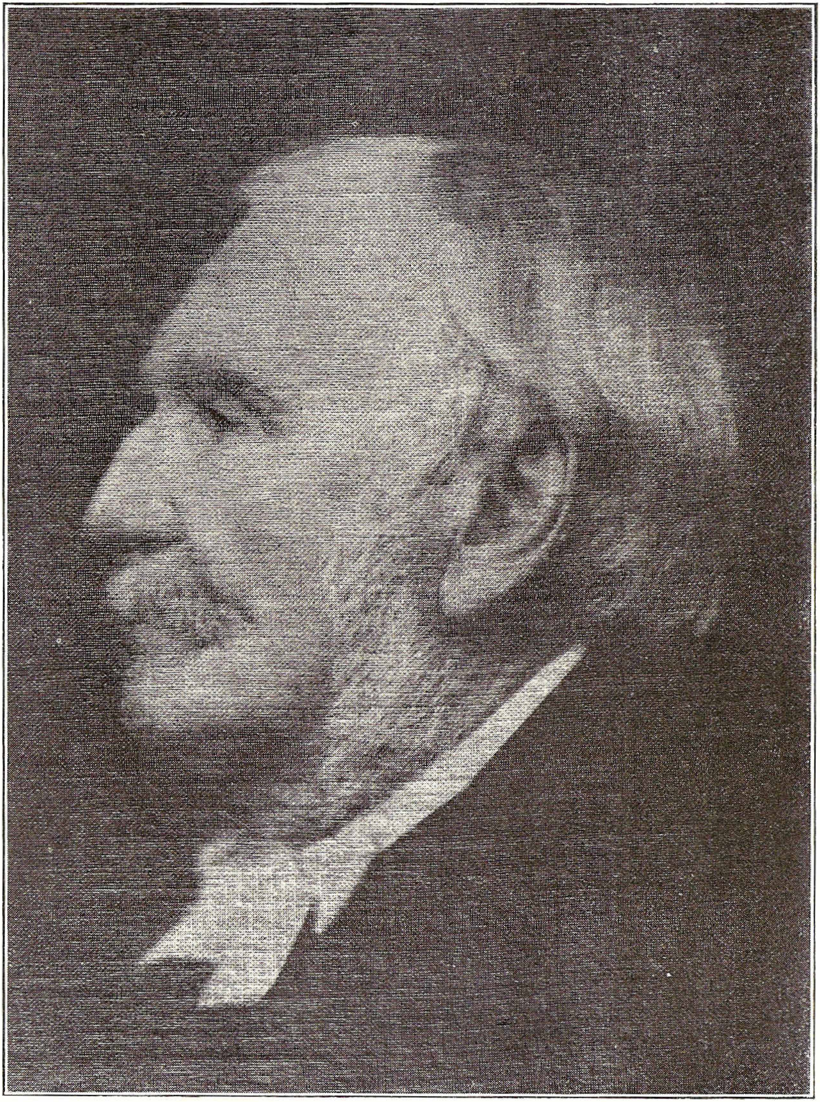
[3] *India. Its Administration and Progress*, by Sir John Strachey, G.C.S.I., pp. 272, 273.

consequences. To his active support is largely due the initiation of measures for preventing the destruction of the Indian forests and for their scientific protection and management. He it was who first organized the great Department of Public Works and laid the foundation of the scientific study of meteorology. He was the first, many years ago, to advise that reform of the currency which has now been carried out." Soldier, engineer, financier, botanist, meteorologist, geologist and geographer, Richard Strachey left his mark on India, and particularly on the Indian railways.

In 1839, shortly after his arrival in India, Strachey joined the Bengal Engineers and served in the First Sikh War and on the Jumna and Ganges Canals, and in 1846 he journeyed into Tibet as far as Lake Rak Tal, mapping the country as he went and making geological and botanical collections of great permanent value. It was in 1862, however, that he came to the fore as Secretary in the Public Works Department at Calcutta in succession to Colonel Henry Yule. Previous to this appointment he had been Consulting Engineer for Railways for nearly four years. As Secretary, P.W.D., Strachey was the technical engineering adviser to three Viceroys—Lords Elgin, Lawrence and Mayo—and, as a member of the Supreme Council, had great influence. Leaving India in 1871, he was appointed by Lord Salisbury in 1875 to a seat on the Council of India and was sent out, two years later, to arrange details connected with the purchase of the East Indian Railway by Government. Afterwards he presided over a Famine Commission and acted as Finance Member of the Government of India. Again a member of the Council of India from 1879 to 1889, he passed on to the Chairmanship of the East Indian Railway Company, bringing that company to a financial prosperity which was unique and advising on all its more important developments almost to the date of his death in 1908.[1] Richard Strachey was one of the finest administrative engineers that India has produced, a man whose wide interests and profound knowledge enabled him to see every side of a problem, to find the best solution, and to put it into practice with economy, energy and common sense.

There is a facetious saying that young Royal Engineers, on joining the Indian Railways, " are unable to distinguish a fish-plate from a soup-plate ! " But a Corps which has given those railways such men as Strachey, James Browne, Bisset, Lindsay, Scott, the two Gardiners, C. H. Cowie, Firebrace, Burn-Murdoch, Elliot, Conway-Gordon, Sargeaunt, Pringle, Capper, Brackenbury, Cameron, Mullins, Shelley, H. E. C. Cowie, Hearn, Waghorn, C. A. R. Browne, Freeland, Magniac, Bonham-Carter, Murray, Craster, Hepper, Hopkins, Walton, Watson, E. P. Anderson and Stallard, to name some admin-

[1] A biography of Lieut.-General Sir Richard Strachey appears in the *History of the Corps of Royal Engineers*, Vol. III, by Colonel Sir C. M. Watson, K.C.M.G., C.B., pp. 255–258. A Memoir by Lady J. M. Strachey appears in *The R.E. Journal*, Vol. VII, Jan.–June, 1908, p. 309.



LIEUT.-GENERAL SIR RICHARD STRACHEY, G.C.S.I., F.R.S., I.L.D.,
LATE ROYAL (BENGAL) ENGINEERS.

istrators and constructors taken at haphazard, has done its duty by India. These, and many others, learnt every technical detail of their special branches after their arrival in the country, and turned this knowledge to good account. They owe a debt of gratitude to the eminent civil engineers who taught them their trade.

Royal Engineers, serving on the Indian railways, are found either on the Engineering side or the Traffic and Management side. Men have changed from one to the other—such as Colonels Sir Gordon Hearn, C.I.E., D.S.O., and Sir Cusack Walton, D.S.O., who finished their service with some years of management after many years of engineering—but usually a man has remained in his selected branch. He has been liable, however, to be moved to any part of India at short notice to engage in new construction or to join a new management, and so we find the same names cropping up in places as far separated as Upper Burma, Madras, and the North-West Frontier. Some traffic engineers have served mostly in a particular province; but most of the men on the engineering side have been wanderers over the face of India, and this greatly complicates the task of writing a narrative of the connection of our Corps with modern railway development in the country. Perhaps the most interesting method of illustrating this connection is by personal narratives, and so, by the exercise of some tact and much persistence, the author has induced several Royal Engineers, with long experience on the Indian railways, to put pen to paper. Their stories of work on the plains of India and Burma appear in this chapter, while their descriptions of survey and construction beyond the Indus will be given in Chapter IX. The "traffic" men will lead the way, to be followed in due course by the "engineers."

We begin with Major A. D. G. Shelley, a Royal Engineer, now retired, who arrived in India in 1883, joined the Railway Department in Madras in 1888, and seven years later, when only 33 years of age, became Agent of the South Indian Railway. This post he occupied until 1906, when he became Agent of the Bombay, Baroda and Central India Railway. In 1916, two years after leaving India, he was appointed Chairman of the London Board of the B.B. and C.I. Railway, an office which he still holds, in addition to a Directorship of the East Indian Railway Company. Shelley's success as an administrator is shown by the fact that, while he was Agent of the South Indian Railway, the dividends rose from 3½% to 7½% and the Company changed from a very modest concern into a first-class organization. While he was in Southern India he was associated with several other Royal Engineers employed on the Madras Railway or the Southern Maratha Railway. Among these were Lieut.-Colonel J. Burn-Murdoch, Agent of the Southern Maratha Railway from 1894 to 1908, when the line was amalgamated with the Madras Railway;

Lieut.-Colonel R. Gardiner,[1] who became Chairman of the Madras Railway in 1910 in succession to Lieut.-General J. Mullins;[2] and Lieut.-Colonel H. Bonham-Carter, who was Agent of the Madras Railway from 1902 to 1908, and is now a Director of the Madras and Southern Maratha Railway.

Major Shelley writes :—[3] "As most of my Indian career was spent in the Public Works Secretariat and in Railway Management I have little engineering to my credit.[4] In 1888 the Indian railways, especially the metre-gauge lines, were far behind present-day standards. For instance, the passenger coaches of the South Indian Railway were loosely coupled by central draw and buffing gear so that passengers had a very rough time when trains were started or stopped. No one journeyed by this line if they could avoid doing so; the trains were very slow and the stops at the stations were long. A Resident Engineer of the railway once found himself travelling in a compartment with three strangers who gave such free vent to their opinions that he thought he ought to defend his employers. He had just begun his speech with 'Well, gentlemen, I have been on this railway for 17 years,' when one of the trio seized his hand and said, 'Poor chap! *And when do you expect to get off it?*' At the time of my departure, however, in 1906, the South Indian Railway was no longer regarded as below the average standard. The B.B. and C.I. Railway, to which I went as Agent, was in the throes of expansion and the work was heavy; but a splendid man was then Chairman of the Company, Colonel Sir William Bisset, K.C.I.E., late R.E., whom I had met first in 1895 when he was Director-General of Railways. Bisset's work, from the time he became Manager of the Rajputana State Railway in 1875 till he relinquished charge of the combined Rajputana–Malwa and B.B. and C.I. Railways in 1893, was masterly in the extreme."

Brigadier-General Sir Valentine Murray, K.B.E., C.B., C.M.G., late R.E., who finished his management career on the Eastern Bengal State Railway in 1914 and rose to be Director of Railway Traffic in France during the Great War, says that the great Railway Sappers in the late 'eighties were L. Conway-Gordon, R. A. Sargeaunt, M. C. Brackenbury, G. F. Wilson and R. Gardiner, but that all these men, like himself, were practically on the administrative side only.[5] Another eminent railway administrator of modern times, Brigadier-General Sir William Danvers Waghorn, C.B., C.M.G., late R.E., pays a tribute to some of the civilian experts with whom he was associ-

[1] His son, Major A. Gardiner, R.E., was Deputy-Agent of the Oudh and Rohilkhand Railway in 1914 and was killed in France during the Great War.

[2] General Mullins had been a Director since 1884 and Chairman since 1899.

[3] Letter from Major A. D. G. Shelley to the author, dated April 2nd, 1933.

[4] Nevertheless, in his early days in India, Shelley was partly responsible for the design and construction of a 250-feet girder bridge in the Bolan Pass.

[5] Letter from Brig.-General Sir V. Murray to the author, dated March 11th, 1933.

ated early in his career. "I had the advantage," he writes,[1] "of serving under many brilliant and experienced civil engineers; for instance Mr. J. R. Bell, the famous builder of some of India's greatest bridges and the originator of the Bell-bund system; also Mr. E. Stone, Chief Engineer of the East Indian Railway, known as 'precious stone'; also Sir William Johns[2] and Sir Trevredyn Wynne." Waghorn started his railway career in October, 1889, on the East Coast State Railway which was being built on the route between Madras and Calcutta chosen by Sir Guildford Molesworth and Lieut.-Colonel C. J. Smith, R.E.[3] Afterwards he served in Bombay, and in the South African War under Lieutenant E. P. C. Girouard, D.S.O., R.E.[4] Between 1903 and 1911 he held various administrative posts on the North-Western and Oudh and Rohilkhand Railways,[5] and in 1912, after a deputation to West Africa, became Manager of the O. and R. Railway. He, and Major H. F. E. Freeland, D.S.O., were on leave in England when the Great War began, and were the only Railway Sappers from India who were kept by Lord Kitchener when the others were shipped to Bombay in the s.s. *Dongola*. After the War, Waghorn was appointed Agent of the North-Western Railway, and in 1920 became President of the Railway Board—the first and only Royal Engineer to hold that exalted post, for it was abolished in 1922 on the recommendation of the Acworth Committee.[6]

Brigadier-General Sir Charles Magniac, C.M.G., C.B.E., a distinguished Royal Engineer on the administrative side who served chiefly in Southern India, says[7] that at the outbreak of war in August, 1914, *seven* officers of the Corps were Managers or Agents of Indian Railways—C. H. Cowie on the North-Western, A. Gardiner on the O. and R., C. A. R. Browne on the E.B.S., H. A. L. Hepper on the G.I.P., A. D. G. Shelley on the B.B. and C.I., W. Carew Smyth on H.E.H. the Nizam's State Railway, and he himself on the Madras and Southern Maratha. Thus it seems that, less than 20 years ago,

[1] Letter from Brig.-General Sir W. D. Waghorn to the author, dated May 26th, 1933.

[2] Sir William Arthur Johns, C.B., C.I.E., commanded the British Railway Troops in German East Africa during part of the Great War with the temporary rank of Colonel.

[3] See *The R.E. Journal*, Vol. 19, 1889, pp. 177–179. The original East Coast Railway is now part of the Madras and Southern Maratha and the Bengal-Nagpur systems.

[4] The railway expert of Egypt and the Soudan who, as Colonel Sir Percy Girouard, K.C.M.G., D.S.O., was Governor of East Africa from 1909 to 1912. (See Memoir in *The R.E. Journal*, Vol. XLVII, June, 1933, pp. 323–343.)

[5] The Oudh and Rohilkhand Railway was amalgamated with the East Indian Railway in 1925. It traversed parts of Oudh and Rohilkhand north of the Ganges, and connected at Saharanpur with the North-Western Railway and at Benares with the East Indian Railway.

[6] The Railway Board was established in 1905. Except during the Great War and immediately afterwards, only two R.E. officers ever served as members—Brig.-General Sir W. D. Waghorn, and, for a few months, Lieut.-Colonel L. E. Hopkins. Major-General Sir H. F. E. Freeland was a member during part of the war, and for a time afterwards.

[7] Letter from Brig.-General Sir Charles Magniac to the author, dated March 14th, 1933.

one-half of the dozen important British-owned lines were managed by Royal Engineers. Hardly one is so controlled to-day. Many other traffic experts of the Corps could be mentioned, such as Major-General Sir Henry Freeland, K.C.I.E., C.B., D.S.O., M.V.O., Colonel C. S. M. C. Watson, D.S.O., O.B.E., and Lieut.-Colonel R. H. Stallard, O.B.E., now Deputy-Agent of the Madras and Southern Maratha Railway, but these must suffice. The time cannot be far distant when the Railway Sapper in India will be found only on the strategic or semi-strategic lines of the north.

The responsibilities of railway work are lightened occasionally by amusing incidents, and Major-General A. Brough, C.B., C.M.G., C.B.E., D.S.O., a Railway Sapper of long experience, has some tales to tell which will bear repetition. As every traveller is aware, the wheels of railway carriages are tapped with a hammer to ascertain that they ring true and have developed no faults. At a certain station there was an ancient Indian who, for 30 years, had tapped the wheels of trains carrying thousands of trusting passengers. One day an inquisitive traveller hailed him with "Old man! Why do you tap the wheels?" "God knows," mumbled the ancient. "But that is the order."

Writing of the almost pathetic faith which the average passenger used to have in the reliability of the railway staff, General Brough says:—[1] "When I first went to India the trains were worked on what was called the "line clear" system, in which a stationmaster telephoned to his neighbour to ascertain if the line was clear. If he was told that it was so, the whole transaction was recorded on a form, one copy of which was given to the driver as authority to proceed. This worked splendidly during the hours of daylight, but was far too great a tax on the patience of a certain *babu* at night. This genius evolved a simple system of writing out the whole of his "line clears" in advance, sometimes for a month ahead, and leaving them in the station office for the driver or guard of any passing train to tear off and use. Needless to say, the result was a number of collisions. The gentle art of producing untrained substitutes for the station staff at a moment's notice was also a source of joy. In one case, when the signalman at an outlying station was taken suddenly ill, a substitute was produced whose sole instructions were, 'If an engine whistles, pull the signal off.'[2] Result—another collision."

One more story, and then to sterner topics. The conversation at a dinner party turned upon the inconveniences of railway travel, and the Chaplain told his Bishop how a certain foreign prince, while touring *incognito* in India, was so much annoyed when a crowd of

[1] Letter from Major-General A. Brough to the author, dated April 28th, 1933. Major-General Brough is one of the few railway officers who have attained this rank on the active list. He became D.D.G. Transportation in the Great War, and his Indian experience was useful at the Railway Training Centre at Longmoor.

[2] Lower the arm to allow the train to proceed.

THE DAILY TRAIN AT JARWA NEAR THE NEPAL BORDER.

Englishmen got into his compartment that he entered the bathroom and locked himself in. "But how uncomfortable he must have been with nowhere to sit," said the Bishop ; then, after some moments of contemplation, "At least, not very commodious." A true story. The author sat facing the Bishop and kept a grave face.

There are few men alive to-day who joined the Indian railways so long ago as the winter of 1874–75, when Lieutenant (now Colonel Sir Buchanan) Scott, R.E., became an Assistant Engineer on the Punjab Northern State Railway and helped to survey a route for an extension of that line for 70 miles from Jhelum to Rawalpindi. Scott assisted in building the new line, a work which was begun in October, 1875, and was the senior member of the staff at the opening of the Alexandra Bridge[1] across the Chenab River by H.R.H. the Prince of Wales (the late King Edward VII.) on January 22nd, 1876. He remained on the Jhelum–Rawalpindi construction for another year, and was then appointed to make a survey for an extension to Attock and for a temporary line from Campbellpore[2] to the same place. July, 1877, found him back on the Jhelum–Rawalpindi line, and on September 6th he witnessed the opening of the Empress Bridge[3] across the Sutlej at Adamwahan. Then came the Second Afghan War, during the second phase of which Scott was sent to help Captain (afterwards Colonel) Thomas Gracey, R.E., in reconnoitring for a line from Rawalpindi to Kushalgarh on the Indus below Attock. This was built as soon as possible, as also was the line from Rawalpindi to Attock ; both were through before the hot weather of 1880.

"The work was very strenuous," writes Scott.[4] "Afterwards I had charge of the maintenance of the two lines and made a temporary line from Campbellpore to Attock Fort to assist the building of a line from the Indus opposite Attock to Peshawar. I had to transfer six broad-gauge locomotives and 100 vehicles across the Indus at Attock in country boats, and was advised to remove everything possible from the engines to lighten them. As I was told that I should be held solely responsible for the job, I arranged it in my own way, and, instead of stripping the engines, I retained all the parts, as the engines had steam brakes which could stop them in six inches if necessary. It was a difficult job, but I calculated that three country boats, well braced together, could carry a complete engine, minus the tender. The Lieutenant-Governor of the Punjab, Sir Robert Eyles Egerton, came to see me take one engine across. On the left bank was a large flat shore, but on the opposite side was a high bank with a slope of about 1 in 8. The first engine was hauled

[1] The Alexandra Bridge had 64 spans of 133½ feet and cost over 56 lakhs of rupees.

[2] Near Attock.

[3] The Empress Bridge had 16 spans of 250 feet and cost over 71 lakhs of rupees. Both it and the Alexandra Bridge were of the usual lattice-girder type. Both bridges have now been remodelled.

[4] Extract from notes by Colonel Sir Buchanan Scott, sent to the author on May 10th, 1933.

up this, two yards at a time, by a steam hoist with tackle attached to the front of the engine, the hoist and engine working in unison. At each halt a wooden sleeper was pulled close up behind each pair of wheels. Once the first engine was up the bank it was used instead of the steam hoist, and the remaining five engines and 100 vehicles were successfully crossed over. I telegraphed to the Manager, Lieut.-Colonel E. L. Marryat, R.E., when the first engine was over, and received his congratulations." By a remarkable engineering feat, rolling-stock was thus provided for the trans-Indus line to Peshawar long before the completion of the Attock Bridge.

In April, 1882, Buchanan Scott went on furlough to England and, returning in November, 1883, after a course at Chatham, joined Colonel James ("Buster") Browne, and other Sappers, on the construction of the Harnai section of the Sind–Pishin Railway, which will be described in the next chapter. According to Sir Buchanan Scott, Browne had wired to Colonel (afterwards Lieut.-General) H. F. Hancock, late R.E., the Director-General of Railways, that he could not get civil engineers for work in Baluchistan and wanted Sappers, so Scott set out at once for Sibi, where he met Lieutenant (afterwards Major-General Sir George) Scott-Moncrieff, R.E., on November 27th, and trolleyed with him to the railhead at the Nari Gorge. There we will leave him for a time.[1]

Meanwhile the railway bridge across the Indus at Attock had been completed at a cost of more than 32 lakhs of rupees, and was opened to traffic on May 24th, 1883. This structure, which was designed and erected by Sir Francis O'Callaghan and Mr. Johnson, had three girder spans of 257 feet and two of 308 feet, and an overall length of 1,655 feet. The girders were of double-intersection type, carrying the railway on a floor system attached to the top booms and the Grank Trunk Road on a floor supported by the lower booms. At the time of construction the Attock girders, 26 feet deep, were the largest erected in India. So well was the bridge built that no remodelling was undertaken until 1926.[2] The two 308-feet spans were then replaced by new steel girders erected outside them, and, in the 257-feet spans, the old main girders were converted to continuous girders by the erection of a central pier in each span. This reconstruction was carried out, at a cost of about 25 lakhs of rupees (£185,800), by Mr. W. T. Everall, O.B.E. It was particularly difficult because it had to be executed entirely between the passings of trains. The maximum time available without interruption was three hours,

[1] Buchanan Scott's work after the Harnai Railway Construction was very varied. He became Consulting Engineer for Railways in Calcutta in 1887, went to England in 1888 and was then sent to California and Mexico as General Manager of the International Company of Mexico to administer a property as big as Scotland. He built a town and had the running of three steamships, four hotels and 17 gold mines! In 1890 he returned to India to the Zhob Valley Railway Survey, finishing his Indian service in 1904 after 13 years as Mint Master in Bombay and Calcutta.

[2] Remodelling was then essential. The structure had become very weak. Road traffic had been stopped, and the speed of trains limited to four miles per hour.

and usually only about one hour.[1] The new bridge was finished in March, 1929, and five months later the great Shyok Glacier dam[2] in the Karakorum Mountains burst and released a gigantic flood, which the bridge withstood successfully. This dam had been expected to break in 1928, and as there were no telephones, beacons had been arranged on the hills to warn people of the approaching deluge. Unfortunately in 1928 somebody lit one of these beacons prematurely and the alarm came to Lahore and Simla that the barrier had burst. Actually it did not burst till twelve months later, but several newspapers seized time by the forelock and came out with glowing accounts by eye-witnesses of the devastation caused by the raging waters!

The most spectacular feat of railway construction in Northern India was performed by a military engineer. Every tourist, who explores the country thoroughly, visits the Khaibar Pass; but not every tourist knows that the marvellous line which threads that Pass in so unobtrusive a manner is the work of Colonel Sir Gordon Hearn, C.I.E., D.S.O., late of the Royal Engineers. The Khaibar Railway will be described in the next chapter, but some details of the career of its builder may be given here. Hearn had more varied experience in the course of his 32 years' service[3] on the Indian railways than any engineer of his time, for he was 5 years on open-line work, 8 years on railway survey, 5½ years on construction, and 2½ years as a Government Inspector. For six months in almost every year he was in the field. He worked in every large province, including Burma, in every minor province except Central India, in many Indian States, over the administrative border on the North-West Frontier, in Afghanistan, and up to the boundaries of Siam. Obviously such a career between 1894 and 1926 must include many interesting experiences, and a few of these will be recorded in these pages.

In 1894 young Hearn was sent to Sukkur on the Indus to watch a section of line on the North-Western Railway between Ruk and Jacobabad which had been lowered to pass a great flood, and to patrol the line to Khanpur. "I remember being nearly run down one night by two engines," he says,[4] "and every morning numbers of snakes could be counted which had been run over. Later I was supposed to patrol to Radhan where there was a breach on which H. A. L. Hepper was employed. Altogether I had more than 200 miles to overlook. It was intensely hot, and sleep on the roofs of

[1] Article entitled "The Reconstruction of the Attock Bridge across the River Indus on the North-Western Railway, India," by W. T. Everall, O.B.E., appearing in the *Minutes of the Proceedings of the Institution of Civil Engineers*, Vol. 230, 1929–30. Part 2, p. 272.

[2] A wall of ice 4,000 feet long and 490 feet high, impounding a lake 12 miles long. Formed by a glacier blocking a valley. The Shyok dam burst again in 1932, and once again in August, 1933.

[3] Including periods of military duty.

[4] Extracts from notes sent to the author by Colonel Sir Gordon Hearn, dated May 30th, 1933.

rest bungalows was only possible if they were well watered. The vast expanse of flood had made a dry heat humid. My fingers became wrinkled as if I had been doing laundrywork. In 1895 my jurisdiction extended from Dadu *via* Ruk Junction to Sibi, beyond which the Harnai Railway led to Quetta. The Mushkaf–Bolan 'cut-off' was then under construction, Lieutenant E. Barnardiston, R.E., being one of the Assistant Engineers. The section from Jacobabad to Sibi had been built with great rapidity by Mr. J. R. Bell during the Second Afghan War.[1] The country was a flat desert with a constant mirage in summer except during floods. Some of the crossing-stations bore the names of R.E. officers—Lindsay for example. Every drop of water required for the station staffs and permanent-way gangs had to be railed out once a week or oftener from Jacobabad. Passenger trains ran by night only, and even so one or more passengers might die of heat apoplexy." This was Hearn's introduction to railway-work in India.

The year 1899 found him on famine relief work in Central India and Rajputana.[2] "The people were reduced to mixing the bark of trees with their grain," he writes, "and occasionally my horse would shy at a corpse on the tracks. Cholera raged in the relief camps, but we escaped. There was no grass for the cattle, which were driven into the forests where we were working and there fell a prey to the tigers which were fairly numerous. A panther killed a sheep close to my tent, and a tiger tried to kill a bulldog belonging to my only European subordinate. Everyone and everything suffered."

Soon afterwards, Hearn was posted to the Mysore and West Coast Railway Survey in Southern India, regarding which he says :—"The only rail connection from Mysore to the sea-ports of Tellicherry and Cannanore involved a great detour through Bangalore and Jalarpet[3] and by the Madras (later the South Indian) Railway which was being extended up the coast towards Mangalore. Alternative routes were to be surveyed, one to Tellicherry and the other to Mangalore, and the division allotted to me was the *ghat* section of the Tellicherry route.[4] Except where the ground had been cleared for growing coffee, the hillsides, rising some 2,000 feet above the coastal districts, were clothed in dense forest which looked black and gloomy when viewed from the sunlit cart-road. Some work had been done in the

[1] See Vol. I, Chapter XIX, p. 387. 133½ miles were completed in 101 days. The Chief Engineer in supreme charge was Lieut.-Colonel J. G. Lindsay, R.E., under whom Mr. J. R. Bell and other engineers worked. The line was opened to Sibi on January 27th, 1880.

[2] Other R.E. Railway officers on similar duty were Lieutenants L. E. Hopkins and A. ff. Garrett.

[3] This is still the case. The line surveyed by Hearn has not been built, and the route from Mysore City through Bangalore, Jalarpet, Erode, Podanur and Calicut to Cannanore and Mangalore forms almost a circle.

[4] The route was from Mysore City by Fraserpet and Virarajendrapet to Tellicherry, descending through the Periambadi Ghat. This is the *ghat* in which Lieut. P. M. Francis, M.E., made a military cart-road in 1849 (see Chapter V).

previous season in cutting a 'trial line.' A temporary engineer started at the bottom (which in itself is a mistake) and in a month or so had surveyed only a short length along the cart-road when 'Puff-Puff' Groves, the Chief Engineer, descended on him and demanded to know what had been done. The cart-road line did not please him, and he took the engineer out and told him to enter the forest and work out the trial line properly. Now there were innumerable snakes in the forest, mostly 'pit' vipers, and we had met two hamadryads each about six feet long. The temporary engineer asked old 'Puff-Puff' if he really meant what he said, and receiving a forcible reply, shook his head and remarked, 'As a family man, I must decline.' A month's notice was the result.

"Gigantic trees were a great obstacle. I calculated one to be over 150 feet high. At least one herd of wild elephants roamed the forest, but only once did they approach a camp. The normal day's work included eight hours in the field, and it seldom ended before 10 p.m. The length of the *ghat* route was only about 24 miles, but, at the rate of one mile a week, this meant six months' work. Every member of the staff, except myself, suffered from malaria, and, when we were working near the bottom of the *ghat*, prickly heat was a curse. I took off my coat and hung a bath-towel round my neck; and I came out of the forest with the towel wet through. In May the monsoon began its advance, and the rain (about 400 inches a year) brought out innumerable leeches. There was no time to reconnoitre. I had to take the trial line run by the engineer." After reading such an account, can anyone say that the railway engineer does not fully earn his pay?

In 1902 Hearn moved northwards again to the Agra-Delhi Chord Railway Construction, under Major P. Ashworth, R.E., which was to run through the country where Krishna was born and to follow the King's Highway between the two Mughal capitals. It seems that this route for the East India Railway was being surveyed when the Mutiny broke out, and that the engineers escaped only with difficulty. The Mutiny caused a divergence of the original alignment from the right to the left bank of the Jumna, where the line was taken through Hathras and Aligarh to Ghaziabad, so that the junction of the East Indian and Great Indian Peninsula Railways was made at Tundla on the left bank opposite Agra. As the section of the B.B. and C.I. Railway from Bombay, linking Nagda to Muttra, was soon to be made on the 5′ 6″ gauge, and that railway would need a direct route from Muttra to Delhi, the early completion of an Agra-Delhi Chord Line through Muttra was most necessary. It was built accordingly to a high standard to carry the traffic of both the B.B. and C.I. and G.I.P. Railways, bull-headed rails of 85 lb. weight per yard[1] being used, laid in heavy chairs on wooden sleepers and

[1] Modern traffic in India now often demands the use of 115 lb. per yard rails, *e.g.*, for "heavy mineral" lines.

good stone ballast. The laying of the track in Hearn's subdivision from the Agra end was completed in June, 1904, in spite of a strike of the imported Punjabi labourers. These men soon got tired of waiting to be paid off, and so brought a supposedly dying man to groan piteously in the verandah of Hearn's quarters. His instant removal was ordered, but with no result, so out rushed Hearn in a fury. At once the crowd scattered and ran, and among them, the fleetest of all, the "dying" man! Roars of laughter from pursuer and pursued then restored good humour. The work was lonely, and malaria was rampant during the rains; but supplies, including fresh meat and ice, were brought daily in all weathers from Muttra, 25 miles away, in the little pony carriages called *ekkas*. The drivers used to give their ponies a mixture of ground grain and molasses, smeared on the back of the tongue, and this helped to support the wiry animals on their 50-mile journey.

In December, 1904, Hearn took charge of the work at the Delhi end. "To connect with the East Indian Central Station," he says, "some demolition of the old walls and of the Kabul Gate was necessary, and a large new station (Delhi Sadr) was built on Government land on which a number of 'squatters' had already encroached. My predecessor had pulled down some shops without proper authority, and the owner was claiming Rs. 33,000 as compensation and had refused arbitration. I asked the claimant if he would accept my arbitration, as I had been no party to the demolition. To my surprise he agreed, but it took me some months of enquiry before I awarded Rs. 3,300, or one-tenth of the claim. To my still greater surprise, this was accepted. Needless to say, the arbitrator got no remuneration."

And now to Burma, regarding which Hearn writes:—"Three new lines were projected in 1906. One was from Thazi[1] on to the plateau of the Southern Shan States; another from Moulmein in Tenasserim to the Siamese frontier, with a possible extension to Myawadi;[2] and a third from Maungdaw[3] to Buthidaung[4] in Arakan in connection with a steamer launch service between Buthidaung and Akyab. The routes led mostly through mountainous country. The Southern Shan States project was in its second year, but I did not agree with the line selected to lead to a certain pass, so, on arriving at Kalaw[5] on the plateau, I made a reconnaissance which involved a walk of 18 miles over very rough country and resulted in the discovery of a more suitable pass. It seemed possible, however, that a line could be found emerging at Yamethin[6] instead of Thazi, but the engineer sent to reconnoitre could not find a feasible route, although

[1] About 12 miles east of Meiktila (see Map II at the end of this volume).
[2] A town on the frontier about 64 miles E.N.E. of Moulmein.
[3] A town about 64 miles N.E. of Akyab.
[4] A coastal town about 52 miles N.W. of Akyab.
[5] About 35 miles E.S.E. of Thazi and 48 miles from Meiktila.
[6] About 50 miles S.E. of Meiktila and 40 miles south of Thazi.

he discovered a hillside on the way from Thazi to the second pass which was suitable for several reversing switchbacks, and eventually this new route was surveyed in detail and the railway constructed to Kalaw. It has since been extended to the Inle Lake[1] just short of Taunggyi. This trip involved walking some ten miles a day for three weeks. On the slopes of the plateau were toucans, pheasants and the Hoolock ape, the nearest approach to man in the animal world. The speed with which the Burmans built a shelter for the night made it unnecessary to carry a tent, but they are not industrious workers, and being sensitive to the sun's rays, would not toil when the sun was high. In fact, the only sound to be heard at mid-day was a snore ! "

After the plateau reconnaissance came another between Moulmein and Myawadi in the southern province of Tenasserim which the British had annexed after the First Burma War. Moulmein is a great centre of the teak industry, in which elephants are largely used to shift the logs. " It stands," says Hearn, " on a ridge with pagodas surmounting it, but not ' looking eastwards to the sea.' Nor did I ever observe ' the dawn come up like thunder,' while, geographically, it could not come ' out of China 'crost the Bay.' " To the east, the floods of the Salween River often cover the ground to a depth of about 12 feet, and when higher tracts are reached the dense forest makes survey work difficult. The country then becomes very rough up to the Siamese frontier. When Hearn visited the district the frontier portion of the reconnaissance was in the charge of Captain E. Barnardiston, R.E. The route has been surveyed in recent years by Lieut.-Colonel M. T. Porter, M.C., R.E., but no railway has yet been built. Leaving Tenasserim, Hearn visited the Pegu-Martaban Railway, which was under construction in 1906, and then voyaged up the Arakan Coast to the Maungdaw–Buthidaung Railway, north of Akyab, a small line which calls for no special remark. He returned to India in 1907 to take part in a survey for a railway connection between Bombay and Sind.

The country traversed by the Bombay–Sind Connection Railway Survey was found to be so flat that almost any alignment could have been selected to serve the large towns were it not for the cross-drainage and the vagaries of rivers. The purpose of the survey was to find a route which would provide an alternative to a long sea-voyage from Bombay to Karachi or a tedious journey by rail to Ahmadabad and thence through Marwar and along the Jodhpur–Bikaner Railway to Hyderabad and Kotri on the Indus, and so to Karachi. The selected route kept east of Cutch, and surveying proceeded at a great pace through a land whose principal feature is salt. Hearn had the southern section, and Lieutenant E. P. Anderson, R.E., the next section farther to the north. A preliminary survey of 100 miles of line, including surveys of rivers, was completed by Hearn in two

[1] The Inle Lake is about 24 miles east of Kalaw.

months, and in another two months he had located and spitlocked the centre-line on the ground. The railway, however, has not yet been built.[1] Hearn left this survey work in 1908 to become Junior Government Inspector of Railways at Dharwar in the south of the Bombay Presidency, and while there he had to visit part of the Madras and Southern Maratha Railway running from Madras to Waltair on the east coast. He says that many complaints had been received about the late running of a certain train on this section, but that, on the day of his visit, the train passed at exactly the right time. Thereupon he congratulated the District Traffic Superintendent on the satisfaction given so promptly to a public outcry. "Thanks," replied the harassed official. "But unfortunately that was yesterday's train, exactly 24 hours late!"

Before the Great War, Hearn was employed on a railway reconnaissance in the region of the Zhob and Gomal Valleys in the far north-west, and during the war served with distinction in France and Belgium; but 1919 found him back again in India and placed in charge of the Indo-Burma Railway Survey which was to be undertaken with a view to establishing railway connection between India and Burma. Three routes had been considered. One route followed the coast from Chittagong to Maungdaw and inland to Buthidaung, and then, avoiding Akyab, ran down the coast until it crossed the Arakan Yoma Range by a suitable pass and joined the Rangoon-Mandalay line after being carried over the Irrawaddy by a bridge. This route had been partly surveyed about 1909. A second route, through Manipur State, presented such difficulties that it had been rejected in favour of the Hukong Valley route, an extension of the Mandalay–Myitkyina[2] Section of the Burma Railway to connect with Sadiya, which lies on the Brahmaputra River in the extreme north-east corner of Assam. This was the route, traversing the mountainous territory of the Kachins and Singphos, which was now to be surveyed in detail. But the outbreak of the Third Afghan War interrupted the operations. Hearn was called to the North-West Frontier and was soon reconnoitring for a line towards Afghanistan which took shape eventually in his masterpiece, the Khaibar Railway. The tale of that work must come later. He finished his railway service as Agent of the Eastern Bengal Railway, proceeding on leave pending retirement in February, 1926. It is safe to say that no railway engineer in India has had a more varied and interesting career than Colonel Sir Gordon Hearn.[3]

Another Royal Engineer, whose railway work took him to the

[1] A railway is urgently needed to connect the progressive city of Ahmadabad with the wheat-growing province of Sind.

[2] Myitkyina is the present terminus of the metre-gauge line in Upper Burma. It lies on the Upper Irrawaddy about 250 miles north of Mandalay.

[3] The statistics prepared for the Railway Board by their able Publicity Officer, Major F. H. Budden, M.C., R.E., showed remarkable financial and operating improvements in the E.B. Railway during Colonel Hearn's tenure.

extreme limits of India and beyond them, is Lieut.-Colonel L. E. Hopkins, D.S.O., O.B.E. He helped to mark the route for the Southern Punjab Railway across 200 miles of flat country in 1894, reaching Bahawalpur on the Sutlej in June, 1895, in a shade temperature of 119°.[1] In the following December he went to Burma to survey for a railway from Mandalay north-eastwards through Maymyo towards Lashio[2] and the Chinese frontier near Kunlon. This was an interesting project involving four reversing stations in the first rise of 1,000 feet from the plains. The only other R.E. officer with the original party was Lieutenant W. A. Watts-Jones, who afterwards crossed the Salween River and entered the Yunnan Province of China, where he is believed to have been murdered, but another Sapper, Lieutenant E. T. Rich, joined the party later. The present delightful hill-station of Maymyo was only a small village with one rest-house when Hopkins saw it first in January, 1896. In spite of the depredations of malaria among the staff, the survey was carried successfully to beyond Lashio, and Hopkins then surveyed for a line southwards from Lashio towards Siam, though this railway has never been constructed. His later service was mostly in Persia, and on the North-West Frontier, and will be dealt with in the next chapter; but it may be mentioned here that he became Chief Engineer of the Eastern Bengal Railway in Calcutta in 1919 after war service in France and on the Indian frontier, and in 1922 was appointed Senior Government Inspector of Railways in Calcutta, where Lieut. Colonel C. J. Clarke, R.E., occupied a similar post, Lieut.-Colonel H. A. Cameron, R.E., was Agent of the E.B. Railway, and Lieut.-Colonel Gordon Hearn, D.S.O., R.E., was Chief Engineer of that railway. As Senior Government Inspector, Hopkins did excellent work in improving the interlocking plans of large stations and in the investigation of impact effect on bridges through the medium of a small committee under Mr. L. H. Swain, an expert mathematician.[3] Before he retired in 1926, Hopkins was Chief Engineer to the Railway Board, and for a time a member of that Board, and while at Simla he was asked to advise the Nepal Government about a railway to their capital at Katmandu. He visited that distant town, but the railway was not constructed beyond the border foothills.

Work was started by Captain S. L. Craster, R.E., in 1895 on a railway line along the left bank of the Indus between Mari and Attock, and in October of that year Lieutenant H. E. C. Cowie, R.E., joined as an Assistant Engineer and was allotted 15 miles of line, including three tunnels, one of which (at Chab) was 1,312 feet long and cost

[1] Notes by Lieut.-Colonel L. E. Hopkins, D.S.O., O.B.E., R.E. (retd.), sent to the author on March 22nd, 1933.

[2] 130 miles N.E. of Mandalay. A line was built subsequently from Mandalay to near Lashio and has recently been extended northwards to Musa. The actual terminus of the Mandalay–Lashio line was Kunlon Ferry on the Salween River. This line contains the remarkable Gokteik Viaduct.

[3] *Railway Board Technical Paper* No. 247 of 1926.

nearly three lakhs of rupees. At the south face the Chab tunnel pierced some conglomerate which was most dangerous when moist. In June, 1897, pieces weighing several tons were falling from the roof of the tunnel before the timbering was erected, and the holes so formed continued to drip for hours before it was safe for the workmen to proceed with the timbering.[1] The work was much delayed also by difficulties in getting materials, and the tunnel was not completed until July, 1898. "In those days," according to Cowie,[2] "the names of the great Railway magnates (correspondingly dreaded by Assistant Engineers) were Colonels T. Gracey and W. V. Constable. A proverbial threat was to transfer an erring Assistant to Bhakkar,[3] but Chab was bad enough. It was often impossible to sleep at night without a *bhisti* spraying water over one and the *punkah-wallah* pulling vigorously. All the work was given out on petty contract, and all available Pathans, men and women, could get a job. It seems that the market price for a wife was Rs. 600 paid to the bride's father, but the unfortunate bride was expected by the Pathans to work on the railway to reimburse her husband. Besides myself, other Sapper subalterns on the work were F. G. Turner at Sohan, E. W. S. Mahon, and S. G. Loch, who laid the first line of telegraph poles. The Mari-Attock construction was finished on April 1st, 1899, and from May to September I surveyed for a 2′ 6″ gauge line from Nowshera to Dargai, working under Captain S. L. Craster, R.E. The building of this line, 41 miles long, was begun in September, 1899, and I was on it until I was sent to China in June, 1900."

H. E. C. Cowie was concerned later in two great bridge projects—at Kushalgarh on the Indus below Attock and at Sara Ghat on the Ganges not far from Calcutta. He joined the Kushalgarh bridge-construction project as an Assistant Engineer in June, 1905, and remained on it until it was completed in September, 1907, at a cost of more than 20 lakhs of rupees.[4] The bridge was needed to connect the 5′ 6″ gauge railway system of India with the trans-Indus line, built by Major P. Ashworth, R.E., to Kohat and Thal, at the foot of the Kurram Valley; before its construction the river could be crossed only by a bridge of boats, and the railway leading to Kohat and Thal was of 2′ 6″ gauge.[5] The new bridge was made with two spans, one of 471 feet and the other of 303 feet, designed to carry a standard gauge railway on the top booms and a cart-road below.

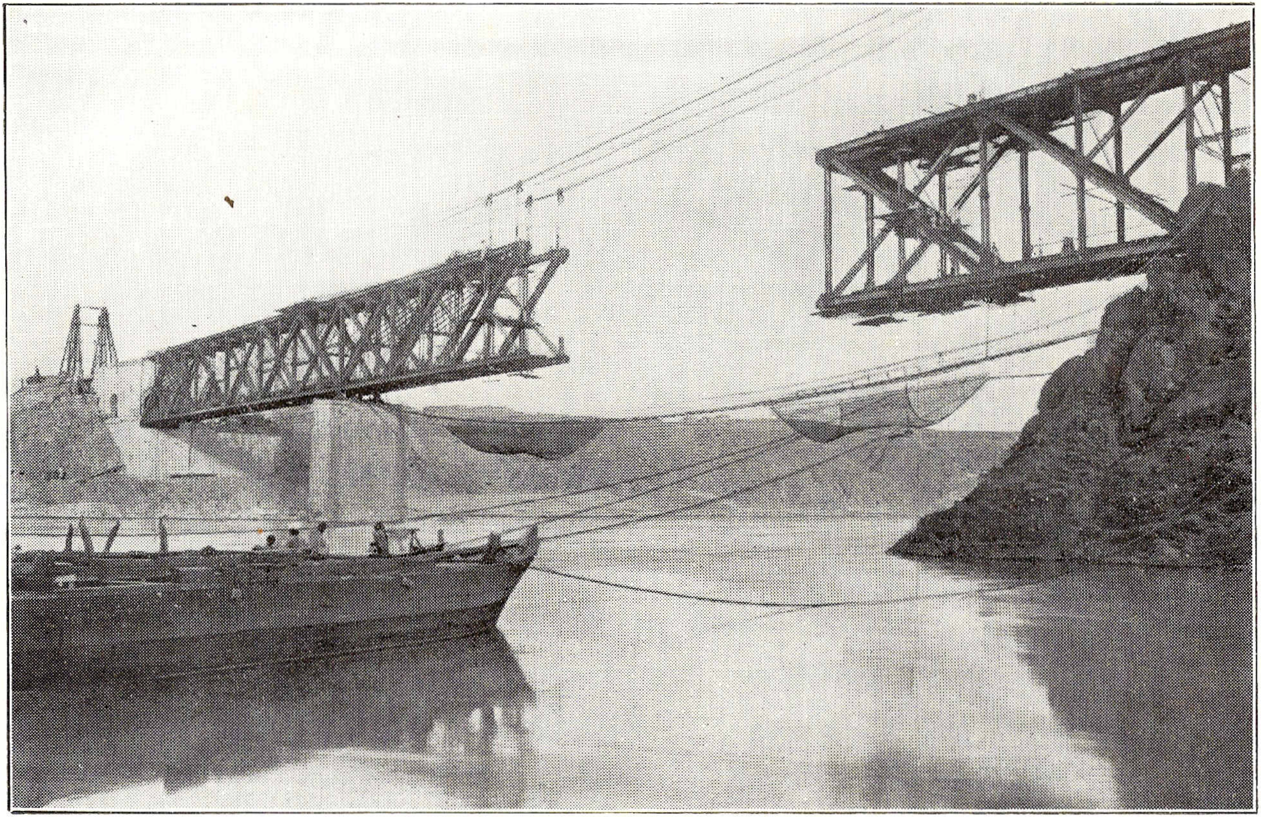
[1] "Simple Tunnel Work on the Mari-Attock Railway," by Captain H. E. C. Cowie, D.S.O., R.E., appearing in *R.E. Professional Papers*, Fourth Series, Vol. I (1905-07), Paper I, p. 1.

[2] Notes by Colonel H. E. C. Cowie, C.B.E., D.S.O., late R.E., sent to the author on April 24th, 1933.

[3] On the Sind–Sagar Branch Railway, opposite Dera Ismail Khan.

[4] The bridge alone cost over 13 lakhs.

[5] It was converted to 5′ 6″ gauge as far as Kohat, in 1906–07, by Captain L. E. Hopkins, R.E., assisted by Lieutenant J. A. P. B. Bowen, R.E., and a civil engineer, the Hon. R. T. R. P. Butler, P.W.D., who joined the R.E. during the Great War, winning the D.S.O. and M.C.



THE KUSHALGARH BRIDGE UNDER CONSTRUCTION, 19TH JUNE, 1907.

Owing to the rocky locality and the great depth of the water, the 471-feet span was built on the cantilever principle with girders 45 feet deep. The erection of both spans was carried out between December, 1906, and July, 1907. "At the actual time calculated for the final riveting up of the 261-feet slung span in the centre of the 471-feet span," writes Cowie,[1] "the temperature happened to be excessively high, but a storm cooled the air and riveting was continued by artificial light until 11 p.m., the temperature meanwhile falling steadily. Next morning, however, the temperature was not high enough to allow us to join up the top booms, but at noon on July 10th the sun came out from behind the clouds and the rivet holes soon came opposite each other. A shout of 'Allah' went up as the order was given for riveting; and by 7 p.m. the 261-feet span was slung."

The completion of the Kushalgarh Bridge improved the strategic position on the North-West Frontier, and reinforced the Attock Bridge, opened in 1883, and the "Lansdowne Bridge" at Sukkur, begun in April, 1887, and finished in February, 1889. The Lansdowne Bridge was erected over the left or Rohri channel of the Indus, which is divided at Sukkur by the island of Bukkur, and is a cantilever structure, resembling the Forth Bridge on a smaller scale, with a clear span of 790 feet.[2] It is a fine bridge, but military engineers took no part in its construction.[3] They shared, however, in the building of the "Hardinge Bridge" at Sara Ghat (or Paksey) on the Lower Ganges, about 70 miles north-east of Calcutta. This is one of the longest bridges in the British Empire; it has 15 main double-line spans, each of about 354 feet and weighing 1,100 tons, and it cost nearly £3,000,000, including £700,000 spent on river-training works. The pier foundation wells were sunk to a depth of more than 150 feet in pure sand. Begun in 1909 with the idea of extending the Eastern Bengal Railway broad-gauge system, south of the Ganges, to Santahar, 80 miles north of that river, and to avoid transhipment, the bridge was opened by the Viceroy, Lord Hardinge, on March 4th, 1915, after giving employment at one time to 24,400 men.[4]

Four Royal Engineers worked for a time on the construction of the Hardinge Bridge on the staff of the Engineer-in-Chief, Mr. (afterwards Sir Robert) Gales. These were Majors H. E. C. Cowie, D.S.O., and Cusack Walton as Executive Engineers, and Lieutenants J. R. Marryat and W. Macrae[5] as Assistant Engineers. A flag was

[1] "The Kushalgarh Bridge," by Captain H. E. C. Cowie, D.S.O., R.E., appearing in *R.E. Professional Papers*, Fourth Series, Vol. II (1908–11), Paper 3, p. 80.

[2] The right or Sukkur channel is crossed by another bridge of three girder spans.

[3] It is interesting to note, however, that some years before the Lansdowne Bridge was built, Lieut.-Colonel James ("Buster") Browne, B.E., designed a single-span hinged steel arch bridge for the Rohri Channel. The design was said to be sound, but it was not adopted because the knowledge of the capabilities of steel was not extensive at that time.

[4] Pamphlet entitled *The Hardinge Bridge over the Lower Ganges at Sara*, p. 6.

[5] Now Lieut.-Colonel W. Macrae, Chief Engineer of the North-Western Railway.

designed for the bridge to combine the Coopers Hill and R.E. colours,[1] for the work was indeed a happy blend of civil and military effort. Cowie had to take sick leave in May, 1912, but he acted twice as Engineer-in-Chief while Mr. Gales was away, and when in England, helped to arrange for the early despatch of machinery and superstructure to India.[2] During the Great War he served in France, and afterwards was Chief Engineer of the North-Western Railway and of the Railway Board. He ended his railway service in 1927 as Senior Government Inspector of Railways in Madras.

An engineer whose name is well known on the Indian railways is Major Sir H. A. Lawless Hepper. Writing of the Sukkur flood-works of 1894 Hepper says :—[3] " Practically the whole country, except the railway embankment, was under water, and we lived in a bungalow on a high patch which we could reach only on a raft. The mosquitoes were the largest I have ever seen, and the whole snake population of the surrounding country appeared to have taken refuge on the railway embankment. After six weeks all the breeches except one had been closed, but the rush of water in that one was so great that no stone would remain in it. The 40-ton covered bogie wagon was a new feature in those days, and one of these was standing in the Radhan yard, so I unloaded it, filled it with stone to the roof, and pushed it down the diversion slope into the breach, where it upset and stuck fast. To complete a stone bank on top of it took 36 hours, but a stream of trains was then released. The Traffic Manager was very proud of his new bogie wagons, and was at first inclined to be critical when he heard how the breach had been closed, but the perpetrator of the outrage finally escaped with a pat on the back." Hepper soon began to specialize in signalling and interlocking and in the lay-out of station yards. He remodelled the Karachi yards between 1895 and 1900, and then carried out the signalling and interlocking of the Lahore and Lucknow yards. In 1901, he patented an " Electric Key Transmitter," which is still largely used on Indian railways in key-locking systems, and in the following year he built the narrow-gauge railways for the Delhi Durbar, assisted by two companies of Sappers and Miners,[4] and remained in charge of them, with Captain C. L. Magniac, R.E., as Traffic Manager. Hepper joined the G.I.P. Railway in 1906, and six years later became its Agent. Under his administration the line was quadrupled from

[1] The flag had a yellow background (sand), crossed by red and blue diagonals (red for the railway, and blue for the river).

[2] It may be remarked here that another fine bridge was completed in Bengal in December, 1931. This was the Willingdon Bridge (seven spans of 350 feet) over the Hugli close to Calcutta, built by Mr. Robert Mair, M.C., to connect the East Indian and Eastern Bengal Railways. Military engineers, however, did not take part in this work.

[3] Letter from Sir Lawless Hepper to the author, dated April 2nd, 1933.

[4] The 4th Coy., Bengal Sappers and Miners, under Captain H. R. Stockley, R.E., with Captain M. R. Elles, R.E., and the 4th Coy., Bombay Sappers and Miners, under Lieutenant F. S. Garwood, R.E.

Bombay to Kalyan, and doubled from Bhusawal to Nagpur; the reversing station on the Thal Ghat was removed, and arrangements were made for the removal of the reversing station on the Bhor Ghat. The electrification of the suburban service between Bombay and Kalyan, and the remodelling of the Victoria Terminus, were put in hand. During the Great War, Hepper entered on the most strenuous period of his career. As Controller of Munitions at Bombay he was responsible for a gigantic railway organization for the shipment and despatch of munitions to many armies. He left the service of the G.I.P. Railway in November, 1920, to take up the appointment of Director of Development in Bombay.

The achievements of many other Royal Engineers on modern railways in India might be recorded. The railway careers of Colonel Sir Cusack Walton, D.S.O., and Lieut.-Colonel E. P. Anderson, D.S.O., are most interesting, but a description of some of the work of these two, which was chiefly on the frontier, must await the next chapter. It may be mentioned here, however, that Walton's administration as Agent of the North-Western Railway at Lahore from May, 1924, to April, 1932,[1] was notable for the tact, firmness and sympathy which he displayed in handling 200 officers and 120,000 men during a heavy programme of new construction and re-organization carried out during a time of political unrest. "Men," said he,[2] "are of more importance than machines. We have specialists to look after our machines. How much more are they needed for the care of the men!" True to his ideals, Walton established a special Personnel Branch to look after the men; he formed Labour bureaux with area councils and staff committees to enquire into grievances, dismissals, etc.; he founded a training school; he improved the men's quarters and gave them every means of recreation and sport; in brief, he treated his employees as men rather than machines. The result was an efficient and contented army of workers when he retired in February, 1933, to receive a well-earned knighthood.[3]

This chapter of reminiscences may close with one by the late Major W. F. Mathews, a Royal Engineer who joined the Eastern Bengal Railway in 1899 and was Chief Engineer of the Oudh and Rohilkhand Railway for several years before he left India in 1925. It may be called "The Tale of the Lost Train."[4] A record flood of the Ganges in 1924 destroyed miles of railway, demolished bridges and dislocated traffic. Between Moradabad and Ghaziabad a section of line crossed the wide depression of the Ganges *khadir* in the middle of which is a tiny station on a small tract of higher ground. A passenger train

[1] He had been Deputy-Agent, under Mr. F. A. Hadow as Agent, from 1920 to 1924.

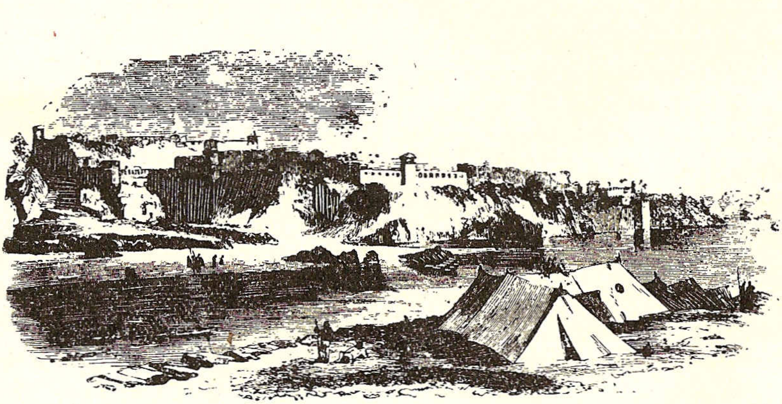
[2] Extract from a speech by Colonel C. Walton delivered at Lahore in 1929.

[3] During Colonel Walton's administration, the railway arrangements for the defence of the N.W. Frontier received particular attention, and the nucleus depot of a Railway Reserve Regiment, many thousands strong, was opened in Lahore.

[4] The tale, a true one, was told to the author by Major W. F. Mathews in Lucknow, and repeated in a letter, dated March 28th, 1933.

from Ghaziabad, crowded with Hindus and Muhammadans, was given permission to enter this section, and from that moment all trace of it was lost. Nobody knew where the train was. The District Traffic Superintendent tried to locate and stop it, but the telegraph wires were down and his message never got through. It seems that the train reached the little station far out in the *khadir*, but could go no farther, as the line beyond it was breached. The driver tried to return, but soon found that the line behind him was breached also, so the train remained in the station on a small island surrounded by miles of water.

As the hours dragged on, the passengers, sitting patiently in their crowded carriages to shelter from the pouring rain, got more and more hungry. By the next morning they were ravenous, and then the trouble started. The Muhammadans noticed that a number of cows had taken refuge on the island and announced that they would kill these and eat them. The Hindus, of course, objected and threatened war. Into the breach stepped a trusty and impartial European guard. Finding a 2nd-class passenger with a gun, the guard borrowed it, and, parading between the rival factions, prevented any bloodshed. Fortunately some hog-deer had been washed down on to the island, so the guard shot a few of these and handed them over to the Muhammadans. By nightfall the train was located. The passengers were removed in boats, but weeks elapsed before the train itself could be rescued from its island home. Who could have imagined that a communal riot of the first order would so nearly develop on a diminutive strip of dry land, isolated from the outer world? It was stopped by the impartiality and courage of a solitary European. Such are the emergencies which occasionally confront the railwayman in India.



ATTOCK FROM THE WEST BANK OF THE INDUS.

CHAPTER IX.

FRONTIER RAILWAYS.

SOME of the railways which stretch across India were built for profit, and others for defence with the expectation of ultimate profit ; but a few were built for defence alone, and it is these which form the subject of this chapter. The frontier railways between Quetta and the Persian border in the west and the Khaibar in the north are peculiarly interesting, not only because they surmount natural obstacles which cannot be matched elsewhere in India, but because they were constructed under conditions often approaching those of actual warfare and in a climate which is unique in its violent extremes. The engineers who surveyed and built these strategic lines carried their lives in their hands. They sweltered in unspeakable heat ; they shivered with malaria, and froze in bitter cold. Success depended on their personal example, courage and resource ; they could not afford to relax. They struggled to get their materials and train their men, and they waged a patient war against those in high places whose natural bent towards economy sometimes blinded them to the danger of invasion through the northern passes. It must be a source of pride to all Royal Engineers that the surveyors and builders of most of the frontier railways have been officers of their Corps, and that these were able to produce such masterpieces as the Sind-Pishin and Khaibar lines.

There is one name in the history of the frontier railways which stands out bold and clear as if painted in letters of gold across the sombre mountain barriers which frown upon the shores of the Indus. It is that of Major-General Sir James Browne, K.C.S.I., C.B., late of the Royal (Bengal) Engineers, who, according to the tablet to his memory in Rochester Cathedral, died at Quetta on June 13th, 1896, at the age of 56 years, when Agent to the Governor-General in Baluchistan. " Distinguished alike as a brave soldier, a scientific and able engineer and an accomplished linguist, he was above all one who ruled over men in the fear of God and won the warm affection of all who served under him, whether European or Asiatic." Thus runs the epitaph of the famous " Buster " Browne, who now re-appears in these pages in the crowning achievement of his career—the building of the Harnai section of the Sind–Pishin Railway.

Browne was peculiarly fitted by nature to wrestle with the problems of frontier railways. Brave, yet never reckless ; fully alive to dangers, but resolute to face them ; a sound engineer, a first-class

mathematician, energetic and cheerful, he inspired confidence and trust in his European staff and their gangs of Indian labourers. But this was not all. He had prepared himself most carefully for railway work, for while on furlough in 1871 he had visited Holland and Belgium to learn marine, bridge and railway engineering, and in 1872 had gone to America where he studied bridge design in New York, Philadelphia, Chicago, Montreal, San Francisco and other cities. It seems that Lord Mayo, the Viceroy, aimed at having cheaper and lighter railways than the engineers of certain companies would consent to build—railways to cost about £8,000 to £10,000 a mile instead of nearly £20,000—and he was searching for Government engineers who would meet his wishes.[1] His successor found one in Browne when the latter returned from America fully primed with modern ideas, and under the guidance of Mr. (afterwards Sir Guildford) Molesworth, Browne then developed into an expert in those steel bridges which play so important a part in mountain railways. His linguistic powers were little short of marvellous, for he gradually acquired a knowledge of almost every language and dialect on the frontier. He was seen, one day, seated at the roadside in the Harnai Pass between a Waziri and a Kandahari, who spoke different dialects of Pushtu, and, as neither could understand the other, Browne was translating between them !

There was constant trouble in Baluchistan before Colonel Robert Sandeman became Agent in 1876, but Lord Lytton and Sandeman began to bring the tribes to order. Quetta was quietly occupied by local troops, and later by a Sikh regiment, and road-making was taken in hand. War against Afghanistan was in prospect. It was important that Baluchistan should remain neutral. So " Buster " Browne was selected to survey for road and railway communications between the Indus and Sibi at the foot of the frontier hills. This he did during the winter of 1876–77 and sent in his report in May, 1877. Eighteen months later came the long-expected war, during the second phase of which Lieut.-Colonel J. G. Lindsay, R.E., built a temporary line of railway with wonderful rapidity from Sukkur on the Indus to Sibi, being greatly assisted by the projects and surveys already made by Browne.[2] At Lord Lytton's request, possible routes for an extension of this railway to Quetta on the Pishin plateau were then examined by Sir Richard Temple[3] and others, and their reconnaissances were followed by surveys of a circuitous route through the Harnai Valley, north of Sibi, for a so-called " Kandahar

[1] *The Life and Times of General Sir James Browne, R.E., K.C.B., K.C.S.I.* (" *Buster Browne* "), by General J. J. McLeod Innes, R.E., V.C., p. 117.

[2] Colonel Lindsay built 133½ miles of line in 101 days (see Vol. I, Chapter XIX, p. 387). The first scheme for a line from Sukkur to Sibi, however, was put forward at about the time of the Indian Mutiny by Mr. W. P. Andrew, Chairman of the Sind, Punjab and Delhi Railway (see Paper No. 1733 entitled " The Kandahar Railway," by Mr. J. R. Bell, in the *Minutes of the Proceedings of the Institution of Civil Engineers*, Vol. LXI, 1879–80, Part (iii)).

[3] Governor of Bombay.

MAJOR-GENERAL SIR JAMES ("BUSTER") BROWNE, K.C.S.I., C.B.,
LATE ROYAL (BENGAL) ENGINEERS.

State Railway" designed to lead eventually into Afghanistan. However, the disaster at Maiwand,[1] and the formation of a new Cabinet under Mr. Gladstone which was pledged to peace and retrenchment, caused the withdrawal of the troops covering the railway operations, and the Kandahar State Railway project was shelved for a time.

The Russians provided the necessary impetus for a renewal of the work. By 1883 their advance towards Afghanistan and India had become so menacing that a strategic line to Quetta became a vital necessity. But it was to be what would now be called a "Hush-hush" line. To save Mr. Gladstone's face it was not even to be called a railway, but was known as "The Harnai Road Improvement Scheme," and no rails or rolling-stock were to be bought.[2] The work was entrusted to Colonel James ("Buster") Browne, C.B., C.S.I., fresh from the command of the Engineers in the Egyptian campaign, and in October, 1883, Browne started his operations with a staff of military and civil assistants. He was to carry a broad-gauge line for heavy traffic through the Harnai Passes, while Lindsay was to construct, at the same time, a lighter line through the Bolan Pass. Both lines were to start from Sibi and to re-unite at Bostan, a few miles north of Quetta. The limiting gradient of the Harnai line was to be 1 in 45, and the minimum radius of curvature, 600 feet, and consequently the length of the line would be about double that of the Bolan line, with its steeper gradients, lighter traffic and partly narrow-gauge track.[3]

Lindsay started work on the Bolan line, but met with an accident and was obliged to hand over charge to Mr. (after Sir Francis) O'Callaghan, C.I.E.,[4] who carried the railway through to Quetta in 1886. To accelerate construction the rails were laid for the most part in the bed of the Bolan River, which is usually dry, though subject to occasional violent floods. The line was of a "rough and ready" type, with steep gradients and a break of gauge, but it formed a valuable alternative to the Harnai railway. "The humble coolie," says a writer in *The R.E. Journal* of June, 1887,[5] "can now travel the whole length of the Bolan Pass from Rindli[6] to Quetta, a distance of 80 miles, for two or three rupees. This time last year, traffic through the Bolan Railway was at its height, and each train had three, and sometimes four, engines. Four 70-ton engines, dragging a heavy

[1] See Vol. I, Chapter XIX, p. 389.

[2] Article entitled "Sir James Browne and the Harnai Railway," by Colonel G. K. Scott-Moncrieff, C.I.E., late R.E., appearing in *Blackwood's Magazine*, May, 1905, p. 609. The restriction regarding rails and rolling-stock greatly retarded the work, for materials could not be transported on temporary railway lines.

[3] Sketch Map III of the North-West Frontier, including Afghanistan, which is included at the end of this volume, will assist the reader in locating many places mentioned in this chapter, although it does not show railways. The Harnai and Bolan lines are shown in a special map opposite page 148.

[4] The builder of the Attock Bridge and of the Uganda Railway.

[5] Article entitled "The Bolan Railway," appearing in *The R.E. Journal*, Vol. 17, 1887, pp. 128, 129.

[6] Near Dadhar, and about 15 miles west of Sibi.

load up a 1 in 25 grade, make noise enough to wake the dead. As to Hirok, 50 miles from Rindli, it more resembled a hive of bees than anything else. Hirok is the changing station between broad- and narrow-gauge. It is 4,500 feet above sea-level and 4,200 feet above Rindli. After Hirok the broad-gauge ceases and nine miles of narrow-gauge *ghat* line carry the traffic over the summit of the Pass, which is 5,600 feet above sea-level. Here there is another changing station, and then 25 miles of broad-gauge complete the line along an almost level plain to Quetta. This line, from Sibi and Rindli to Quetta, has now been christened the 'Quetta Loop Line.' In October, 1885, on the site of Hirok, there was literally nothing to be seen except a barren plateau of stones without a drop of water anywhere near. In October, 1886, the place had been converted into an enormous railway station, surrounded by stone bungalows, workshops, waterworks, engine-sheds, a hospital, an institute and a bazaar. It is now pretty certain that a broad-gauge line will be made right over the Pass."

The change of gauge in the original Bolan Railway was found to be so inconvenient that some remodelling of the line was soon taken in hand and a complete reconstruction of part of it was begun in November, 1891, the work being known as the "Mushkaf–Bolan Railway." This line, 86 miles in length, was taken along portions of the old alignment with a new length of 57 miles between Nari Bank, near Sibi, and Kolpur, 25 miles from Quetta. The total rise from Sibi to Kolpur is 5,463 feet, and the line was made with gradients varying from 1 in 55 to 1 in 25.[1] A most remarkable feature of the Mushkaf-Bolan Railway is that it is an adhesion line even on its 1 in 25 slopes, that is to say no rack is employed as on parts of the steep Nilgiri Railway in Southern India.[2] Eight tunnels and four crossings of the river were needed to carry the line up the Mushkaf Valley, and three tunnels in the Bolan Valley, with a very long tunnel from one valley to the other. Near Kolpur the engineers made nine large bridges over the Bolan River. Altogether, the Mushkaf-Bolan Railway was a most difficult and arduous undertaking which occupied a large staff of civil engineers for several years. But more space cannot be devoted to it in these pages. We must revert to the doings of Colonel James Browne and his military engineers on the original main line from Sibi to the Pishin Plateau, which was planned to run through Harnai, Kach and Khanai to join the Quetta Loop at Bostan, north of Quetta.

A large and enthusiastic staff of military and civil engineers collected gradually at Sibi to help Browne in his great task. The

[1] The 1 in 25 grade occurs between Ab-i-gum and Kolpur.

[2] The Nilgiri Railway, a metre-gauge line, from Metapalaiyam to Coonoor, was designed about 1880 by M. Riggenbach, assisted by Major J. L. L. Morant, R.(M.)E. It was built many years later by Mr. W.G. Weightman and was opened in June, 1899. Subsequently it was extended to Ootacamund.

Royal Engineers were Major W. Shepherd, Captains W. W. B. Whiteford, C. Hoskyns, Buchanan Scott, W. H. White, G. Davidson and G. K. Scott-Moncrieff,[1] and Lieutenants C. H. Cowie, O. M. R. Thackwell, J. Stewart, H. K. Stothert, J. R. L. Macdonald,[2] S. L. Craster, E. W. Walton, G. S. McD. Elliot, R. D. Petrie, J. E. Capper[3] and H. S. King. Among the civil engineers were Messrs. Fowler, Shadbolt, Savory, J. Ramsay, R. J. Woods, G. P. Rose, F. J. Pope, E. H. Tuck, C. J. Cole and W. A. Johns.[4] It would seem that a staff of some 30 engineers was excessive for a short line, but it should be remembered that the route was exceptionally difficult, that few of the engineers had much railway experience, and that many were young subalterns straight from Chatham. Also, the cadre was never complete because of sickness. The imported gangs of Pathan labourers were stiffened by engineer troops in the shape of the 4th, 5th, 7th, 9th and 10th Companies of the Bengal Sappers and Miners[5] and the 23rd and 32nd Sikh, and 4th Madras, Pioneers.[6]

The Harnai Railway is well described by Major-General Whitworth Porter in his *History of the Corps of Royal Engineers*.[7] "The construction of such a line as the Sind–Pishin Railway," he writes, "was a very different matter from that of carrying out similar work in Europe or even in the plains of India. In the 224 miles of which the line consists, almost every possible constructive problem presented itself for solution. In a distance of 120 miles, a rise of over 6,000 feet had to be gained, which is double that of the St. Gothard Railway. On the way, the most extraordinary difficulties were encountered. These arose principally from the rifts or defiles which had been formed in the mountains by the rivers. Of these, the most important was the Chappar Gorge, about three miles long. In traversing this, the line had to pass through nine tunnels, of a collective length of 6,400 feet; also over a viaduct, 75 feet high, in seven spans of 40 feet, with a bridge over the river at an elevation

[1] Afterwards Major-General Sir George Scott-Moncrieff, K.C.B., K.C.M.G., C.I.E. In 1883 he was Personal Assistant to Colonel Browne.

[2] Afterwards Major-General Sir James Macdonald, K.C.I.E., who commanded the troops in the Tibet Mission of 1903–04.

[3] Now Major-General Sir John Capper, K.C.B., K.C.V.O., Col.-Commandant Royal Tank Corps.

[4] Afterwards Sir William Johns (see Chapter VIII). These civilian names are given in an article entitled "The Sind-Pishin Railway," appearing in *The R.E. Journal*, Vol. 17, 1887, pp. 192, 193.

[5] *History and Digest of Service, 1st K.G.O. Sappers and Miners*, p. 43. The five companies arrived at Sibi in October, 1883. The 4th and 10th left the Harnai Railway in August, 1884, to serve in the Zhob expedition. The 5th, 7th and 9th remained until December, 1884.

[6] General Porter writes (Vol. II, p. 330) that only half-battalions of Pioneers were employed, but General Innes in his *Life and Times of General Sir James Browne*, p. 246, states that three *full* battalions were used. The Sappers and Miners were commanded by Major L. F. Boileau, R.E., one of whose subalterns was Lieut. F. J. Aylmer, R.E., now Lieut.-General Sir Fenton Aylmer, V.C., K.C.B. Capt. Martin Martin, R.E., commanded one of the Sapper Companies.

[7] Vol. II, pp. 329–335.

of 250 feet consisting of a central span of 150 feet and eight of 40 feet each. The other main obstacles were the Nari gorge, 14 miles long, the Kuchali defile, five miles long, and the summit pass, 25 miles long. The line does not wind its way through smiling valleys to the breezy heights above.[2] It traverses a region of arid rock without a tree or a bush and with scarcely a blade of grass—a country in which Nature has poured out all the climatic curses at her command. In summer the lowlands are literally the hottest corner of the earth's surface, the thermometer registering 124°F. in the shade, while cholera rages, although there is neither swamp nor jungle to provide it with a lurking place. In winter the upper passes are filled with snow and the temperature falls to 18° below zero, rendering outdoor labour an impossibility. The few inhabitants that the region possesses are thieves by nature and cut-throats by profession, and regard a stranger like a gamekeeper does a hawk. Food there is none, and water is often absent for miles. Timber and fuel are unknown, and, in a word, desolation writ very large is graven on the face of the land."

According to Colonel S. L. Craster,[3] Browne would probably have preferred the Bolan to the Harnai route if he had been given the choice; but the Government of India, in resuming a "Forward Policy" in 1884, insisted that the Harnai route reconnoitred by Sir Richard Temple should be followed in spite of its extraordinary difficulties, so by this route Browne and his engineers reached the Pishin plateau. "The standard-gauge surveys were finished in three months," says Craster, "and the construction began in November, 1883, the line being opened early in 1887. In about 32 months, 150 miles of line were completed in a country where all labour, food and stores had to be imported, where extremes of temperature were experienced, where floods came down 20 to 30 feet deep at 29 miles an hour, where cholera claimed 5,000 victims in six weeks, and fever prostrated 90% of the gangs in August and September each year, to say nothing of the attacks of tribesmen which gave the line a bad name in India."

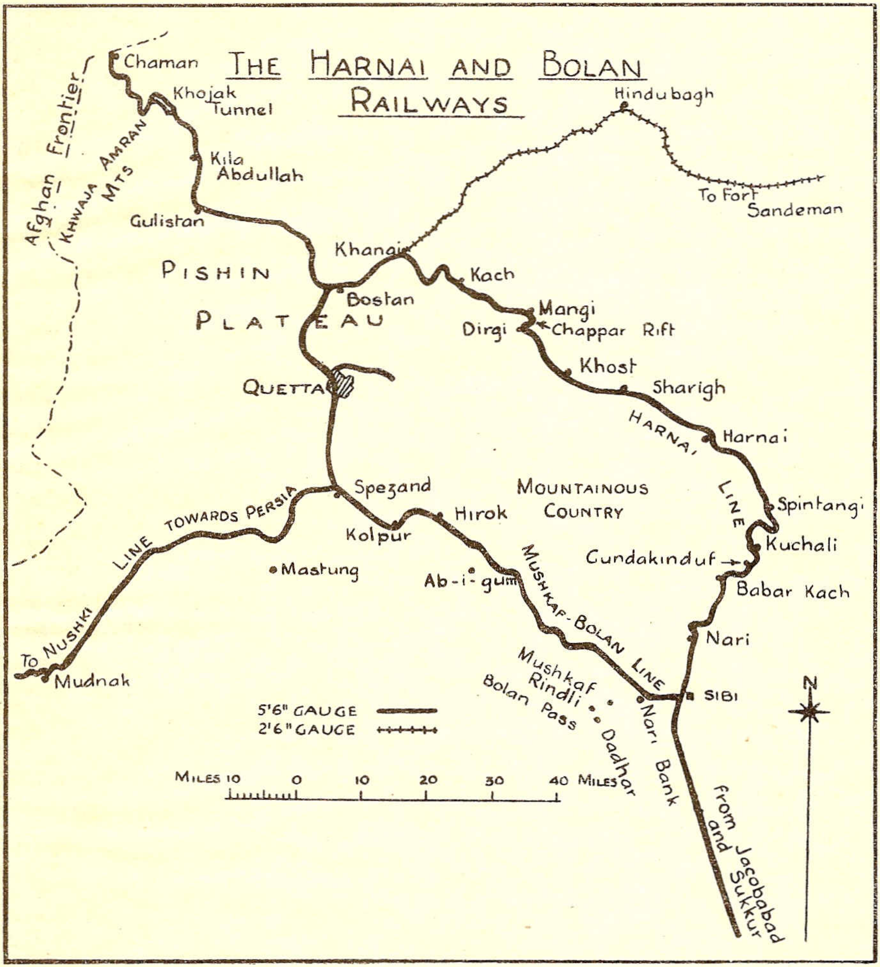
When all did so well, it may be invidious, perhaps, to mention individual exploits; but if a selection must be made, the achievements of Captains Buchanan Scott and W. W. B. Whiteford, R.E., should rank next to those of Brigadier-General Browne, their famous leader.[4] Browne pays the following tributes to these two Executive Engineers in a letter, dated April 19th, 1887, to General Sir George

[1] Sir Buchanan Scott states, however, that the Chappar Bridge is about 225 feet above the river, and that the Gorge or "Rift" is about two miles, not three miles, in length.

[2] General Porter here quotes from an article in *Engineering*, dated April 13th, 1888.

[3] Letter from Colonel S. L. Craster, C.B., C.I.E., late R.E., to the author, dated August 10th, 1933.

[4] The work of Captains Hoskyns, Scott-Moncrieff and Davidson, R.E., was also conspicuously good.



THE HARNAI AND BOLAN RAILWAYS.

Chesney, K.C.B., C.S.I., C.I.E., late R.E., then Military Member of the Viceroy's Council :—[1]

"Scott and Whiteford have had divisions both in the upper and lower sections of the line, tunnel and bridge building, and girder erection and plate-laying, with the temperature *in a house* of 124° Fahrenheit, and the same work with the temperature in the verandah of 18° below zero Fahrenheit with deep snow on the ground and the rivers blocked with ice. Scott, who has been on the line from the very first, has made the whole of the railway for nine miles in the Kuchali ravines with all its heavy tunnelling and bridging, and also drove the headings of the Babar Kach tunnel and secured the most difficult wet foundations of three of the great Nari bridges. He has surveyed and constructed the whole of the 28 miles of the Chappar Division from first to last. He has now made over 2,000 running feet of lined tunnels, mostly in most dangerous and treacherous soil, where, I may honestly say, he for months carried his life in his hands, and where no native would venture without European example owing to the obvious and unavoidable danger to life involved, as shown by the many fatal accidents and grievous injuries which no skill could prevent. He has made over 6,000 feet of rock tunnels in the Chappar Rift,[2] besides erecting over a mile of iron bridge girders. Many of these bridges, like those at Gundakinduf, Kuchali, Dirgi, Chappar and Mangi are very high viaducts. The laying out of the Chappar tunnels, with their reverse curves fixed from rock adits, where often men could only attain at the peril of their lives, was a work needing scientific surveying of the utmost delicacy. The handling and placing of enormous weights in such positions as the Chappar bridge, involving the lives of numbers of men as the penalty for want of courage, skill and precision, represents a sense of personal responsibility and anxiety for many months which it is not easy to overstate. Add to this that, for fully half the time, work was carried on in the face of withering sickness, scarcity of food, cholera epidemics, floods, want of carriage, etc., etc., and some fair idea of Scott's work may be formed."

Of Whiteford, nicknamed "The Cyclone," Browne writes that, where other good men failed, he got things done by an almost incredible power of driving work and getting labour. "I have never met his equal in the power of managing and employing great bodies of men, such as the 16,000 men he had in the Kach Division in June, 1886. I do not believe that for rapidity of construction there is any piece of railway work in India that could approach, certainly not surpass, the manner in which the bridges and culverts of the Kach

[1] These extracts are quoted in part in the *History of the Corps of Royal Engineers*, by Major-General W. Porter, Vol. II, pp. 334, 335.

[2] The firing of the mines required for the tunnels and cuttings in the Chappar Rift was carried out for two hours daily for a period of nearly two years. So heavy was the blasting on the Harnai Railway that Colonel Browne's "Preliminary Order" to Messrs. Nobel was for 100 tons of dynamite !

Division were constructed."[1] But Browne's eulogies of his assistants should not be allowed to detract from the credit which he himself deserves. His was the master mind : his the ultimate responsibility for success or failure. He was everywhere, controlling, advising, cheering the workers, comforting the sick. Scott-Moncrieff records[2] that he often heard men say " I would do this for Buster Browne, but for nobody else." It was Browne's personality that carried the work through, for it was this that inspired his men.

Buchanan Scott arrived in Sibi on November 27th, 1883, and with Scott-Moncrieff trollied up to the railhead at Nari Gorge to meet General Browne.[3] A week later he went on to Gundakinduf, where he relieved Davidson and began to re-mark the line which had been laid out some years before. Each Executive Engineer was placed by Browne in charge of two divisions, one at a low elevation for work in the cold weather and another at a high level for work during the summer, and Scott had the Gundakinduf Division, eight miles long, for the winter, and the Chappar Division, 28 miles long, for the summer. In the Gundakinduf Division under Scott were Capper in charge of the Kuchali bridge-construction and King who was making a long tunnel, but Scott himself built most of the bridges, some of which had two or three spans of 150 feet. Aylmer also worked in this division. The operations were transferred in April, 1884, to the Chappar Division at a high altitude, where the formidable Chappar Rift had to be negotiated. The country between Nari and Kach (beyond the Rift) was a rugged wilderness of rocks with hardly a blade of grass except at Harnai and Sharigh, and with a stony river-bed as the only road.

The Chappar Rift is a deep chasm, some 2½ miles long, joining two parallel valleys. Its cliffs are 200 to 300 feet in height, and the stream which flows down its boulder-strewn bed at a slope of about 1 in 20 is subject to sudden and violent floods. The railway had to traverse this rift, and not only so, but to emerge above flood-level at the upper or Mangi end where three streams met and a bridge was required. As the ruling gradient of the railway was 1 in 45, the entrance at the lower or Dirgi end had to be arranged at a great height. This involved many tunnels and several bridges, including one at a very high level. To ensure rapid excavation of the tunnels it was necessary to work from horizontal shafts or adits driven inwards from the cliff faces at the proper levels. It was difficult to find men brave enough to undertake the work of starting the adits, but eventually a few Kashmiris volunteered to do it. Each man

[1] Colonel Sir Buchanan Scott and Brig.-General G. S. McD. Elliot estimate that Whiteford built about 50 bridges during the working season of 1886.

[2] Article entitled " Sir James Browne and the Harnai Railway," by Colonel G. K. Scott-Moncrieff, C.I.E., late R.E., appearing in *Blackwood's Magazine*, May, 1905, p. 619.

[3] Most of the information which follows was given to the author by Colonel Sir Buchanan Scott, K.C.I.E., late R.E., in notes dated May 20th, 1933.

was lowered in a rope chair from the cliff above, and, using a steel jumper, bored a hole about a foot deep into the face of the cliff at a point previously marked with whitewash. The marking was done by letting down a weighted bundle, soaked in whitewash, at the end of a rope until the correct height for the adit was reached. The bundle was then pulled outwards by a rope from the opposite cliff, and when it was released and swung inwards, it left a mark for the adit. Several holes having been made, and jumpers fixed in them, staging could be erected from which the adits were driven.

The survey of the line in the Chappar Rift was exceedingly difficult. "We had often to go without shoes," writes Scott, "the rocks being too slippery to stand on." Of the engineering work he says, "The high-level bridge, the 'Louise Margaret,' opened by and named after H.R.H. the Duchess of Connaught, was 225 feet above the bed of the river. The design and calculations for the erection of this bridge were most arduous and responsible, and they cost me many months of thought. Only the materials at hand were available. The erection of this mass of iron at such a height was no small problem, about 600 tons of girders being used in the process, but the whole was completed without the loss of a single life, although the workmen were sometimes nearly blown off the piers by the wind. The highest pier is 90 feet from top to bottom. There are six tunnels in the eight miles of the Chappar Division and three large bridges besides the Louise Margaret."

In the summit portion of the line the most serious obstacle was the "Mud Gorge," a narrow, winding and steeply sloping valley, five miles long, which ran through most treacherous soil between precipitous mountains.[1] This gorge once passed, the country was still so rugged that many heavy works were needed and most careful surveying to find the best route. From the summit itself, at an elevation of 6,800 feet, the line descended steeply, by a "corkscrew" at maximum grade, to a rocky pass, and, emerging on to the Pishin tableland, proceeded easily through Khanai to Bostan, 20 miles from the pass and the same distance north of Quetta. It fell to Scott to stake out the critical length from Khost through Dirgi and Mangi to Kach, and in October, 1884, he prepared a drawing of the high-level Chappar Bridge under the guidance of Browne. Soon afterwards he developed fever, but returned in November to set out the centre lines of all the bridges in the lower or Gundakinduf Division, and pushed on their construction while Major W. Shepherd, R.E., prepared estimates and drawings for these works.[2] It was no time to be bound by rules and regulations.

[1] The "Mud Gorge" had a thick bed of yellow clay, containing bands of gypsum, overlying another of purple clay, and both sloped steeply towards the valley below. When water reached the gypsum and its junction with the yellow clay, and caused the gypsum to expand, vast landslips occurred until the gorge was lined with masonry.

[2] No "type drawings" of any bridges for the Harnai Railway were available. Sketch designs were made on the spot, and working drawings were prepared from these.

Within the next few months cholera added its quota to the many tribulations of the workers. It raged at Gundakinduf during the summer of 1885. Scott contracted it and was carried on a litter for 30 miles to a higher spot, and although he recovered he was incapacitated for two months. A telegram had reached the staff in May, during a Russian scare,[1] saying that work must be carried on "even at the sacrifice of lives"; so it was duly carried on, and, out of 20,000 men employed, 1,500 died of cholera in two months and a far greater number before the disease was vanquished. Malaria and scurvy also claimed their victims. "At Chappar in August, 1885," says Scott, "out of four companies of Sappers, each about 100 strong, there were not sufficient men to mount guard owing to fever, and they had all to be sent back to India. I was so ill that our doctor told me to take 75 grains of quinine daily for a week. At the end of the week my digestion was ruined." But enough of such tales of woe. These few extracts show the conditions under which the Harnai line was built.

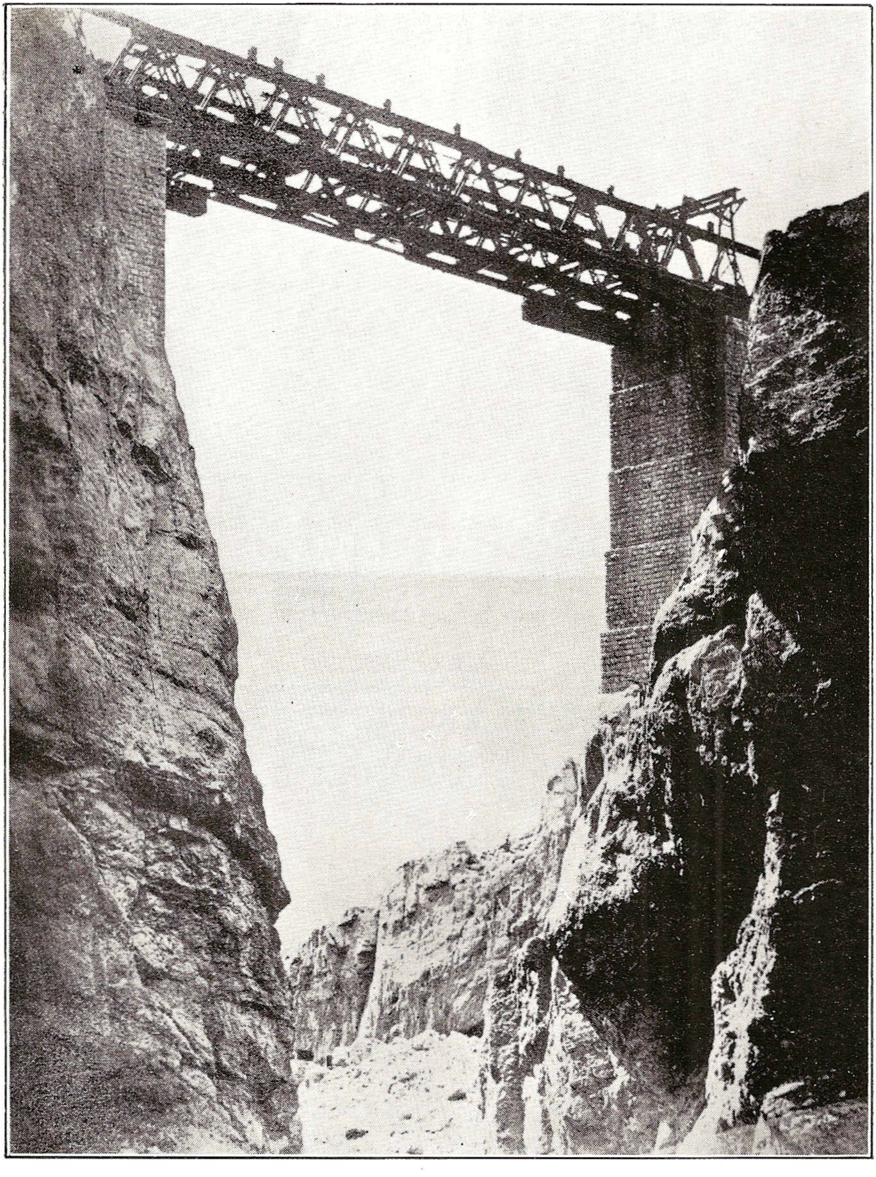
The story of a great exploit is almost told. Railhead reached the west end of the Chappar Bridge on November 22nd, 1886, and Scott soon began to erect the first of its eight 40-feet spans. The girders of the central 150-feet span were erected between December 5th and 9th, and platelaying started on the bridge on the 14th. An engine passed over the structure on February 16th, 1887, and a train on March 10th, while a week later an engine ran right through from Sibi to Quetta. The bridge was opened by H.R.H. the Duchess of Connaught on March 27th, 1887, in the presence of the Duke, Lord Roberts, and a distinguished company, the occasion being marked by the explosion of 20 mines. Buchanan Scott said good-bye to Chappar at the end of April, after 3½ years on the Harnai Railway, and received a well-earned C.I.E. The Sappers and Miners and Pioneers had already gone, and the engineering staff and workmen dispersed gradually, but they carried with them the recollection of the Duchess's remark that the Chappar Bridge was the grandest work in India. The same might have been said of the whole railway. Proceeding on furlough to England, Brigadier-General James Browne was awarded a K.C.S.I. The Harnai Railway was the last and greatest engineering achievement of his career.[2]

While the work on the Harnai section was still in progress the line was prolonged northwards from Bostan and reached Gulistan, on the eastern slope of the Khwaja Amran range, before the first train ran through to Quetta. "The extension of the railway from Sibi to Quetta and thence northwards," wrote a contributor to *The R.E. Journal*,[3] "has increased our strength on the south-east frontier of

[1] The "Panjdeh" incident, wherein the Russians attacked the Afghans and brought England to the verge of war.

[2] He became Quartermaster-General at Army Headquarters in 1889.

[3] Article entitled "The Extension of the Quetta Railway," appearing in *The R.E. Journal*, Vol. 17, 1887, p. 123.



LOUISE MARGARET BRIDGE UNDER CONSTRUCTION, CHAPPAR RIFT, HARNAI RAILWAY.

Afghanistan a hundred-fold, for it has solved the difficulty of transport. We can now concentrate an Army Corps at short notice in Pishin by railway. But the Khojak Pass[1] is trying for heavily laden camels and mules. Were the railway terminus at Chaman instead of at the eastern entrance of the Pass, the march onwards to Kandahar and the Helmand would indeed be simplified." In the autumn of 1887, Mr. F. O'Callaghan reconnoitred for a "Chaman Extension Railway" through the Khwaja Amran range, and at the end of the year the Government sanctioned his proposals, which involved the driving of a tunnel, nearly 2½ miles long, under the Khojak between Kila Abdullah and Chaman. This magnificent work, the longest railway tunnel in India, was practically completed in September, 1891, at a cost of about Rs. 65 lakhs, and on January 1st, 1892, a train ran through to Chaman, on the Afghan border. One of the chief problems of the defence of the southern section of the North-West Frontier had then been solved.

The success of certain railway survey operations on the Kabul River in 1890 under Captain (afterwards Major-General Sir J. R. L.) Macdonald, R.E., led to similar work in the Zhob Valley, which descends north-eastwards from the Pishin plateau. In these and other surveys for frontier railways can be seen the hand of the newly-appointed Quartermaster-General, Sir James Browne, who wished not only to thrust a line towards the Afghan border in the north, as he had done in the south, but to connect Quetta with Attock by a more direct route than that through Sibi, Sukkur, Multan, Lahore and Rawalpindi. "Hundreds of miles of alternative alignments had to be surveyed," says Brigadier-General H. H. Austin.[2] "Hence the command of the survey operations was entrusted to Major Buchanan Scott, C.I.E., R.E., an officer of wide railway experience. Scott organized the expedition into five survey divisions. The Zhob Field Force of 1890, which was assembling on the Harnai Railway near Khanai, marched for the Zhob Valley on October 1st, and three survey divisions commenced work at once from Khanai. One division under Captain (now Colonel Sir John) Pringle, R.E., was to survey down the Zhob from Apozai[3] to Kajuri Kach;[4] another, under Captain (now Brig.-General) G. S. McD. Elliot, R.E., between Apozai and Gul Kach;[5] and ours (Macdonald's) between Gul Kach and Kajuri Kach. The other two divisions, under Captain (now Major-General) C. H. Cowie, R.E., and Captain (now Major-General Sir John) Capper, R.E., were at work between Dera Ismail Khan and the exit of the Gomal into the plains of India

[1] North of Gulistan and Kila Abdullah.

[2] Extract from an article entitled "The Zhob Valley Railway Survey," by Brigadier-General H. H. Austin, C.B., C.M.G., D.S.O., appearing in *The R.E. Journal*, Vol. XLII, 1928, pp. 427–439.

[3] Close to Fort Sandeman.

[4] At the junction of the Zhob and Gomal.

[5] About 25 miles up the Gomal from Kajuri Kach.

below its junction with the Zhob. We were the first Europeans to penetrate the gorge of the Gomal between Gul Kach and Kajuri Kach, and I was the first white man to enter it."

General Austin continues :—" Later we got into touch with one of the survey divisions at work on the Dera Ismail Khan end of the line under Capper. He was camped some $5\frac{1}{2}$ miles down the Gomal below its junction with the Zhob, and was faced by the most difficult problem of the whole Zhob Valley line, that of 'Browne's Gorge,'[1] before entering which the river makes a bend of nearly a complete circle of small radius. The scenery here well-nigh baffles description. Immense precipices of hard limestone rock rise aloft nearly 1,000 feet and almost sheer on both sides of the chasm. Nowhere does this exceed a width of 30 or 40 feet at its base, and the cañon twists and turns bewilderingly while the combined waters of the Zhob and Gomal surge furiously down the narrow winding cleft for a distance of $\frac{3}{4}$ mile. In times of flood, so tremendous is the struggle by the impounded waters to force their passage through this puny aperture that they become banked up to a height of 60 feet above the normal cold-weather level."

Macdonald's men surveyed up the Gomal from Kajuri Kach towards Gul Kach, but were so hampered by rain, floods, gales, frost and the difficulties of the ground that it was not till February 16th, 1891, that their work was joined up at Gul Kach with that of Elliot's division, which had been surveying down from Apozai. The surveys proved, however, that the Zhob route between Apozai and Kajuri Kach was easier than the Gomal route through Gul Kach. Operations in the field ended in May, and Scott and his officers then returned to Quetta. It may be remarked here that no attempt has yet been made to connect Quetta by a broad-gauge line with Dera Ismail Khan through the Zhob and Gomal Valleys, so Scott's surveys might seem to have been wasted. But who can tell when such a line may be needed, and needed urgently ? The surveys of 1890-91 have been valuable in the construction of the light 2′ 6″ gauge line which now takes off the Harnai Railway at Khanai and runs through Hindubagh[2] and Kila Saifulla to remote Fort Sandeman on the Zhob.

Buchanan Scott's surveys resulted in some interesting memoranda by General Sir Frederick Roberts, V.C., then Commander-in-Chief in India, and by Major-General Sir James Browne, his Quartermaster-General. Roberts wrote :—[3] " The questions before us are whether

[1] So called because " Buster " Browne is said to have been the first European to view it. The local name is " Dosakh Tangi," or Hell Gorge.

[2] The survey of the Khanai–Hindubagh section was carried out in 1908–09 by Captain (now Colonel Sir Cusack) Walton, R.E., but the construction did not take place until 1916–17, when the line was built as a " war line " to bring chrome ore from the Hindubagh deposits for shipment from Karachi to England. Metre-gauge rolling-stock and permanent way were then supplied by the Indian railways.

[3] Memorandum by General Sir F. Roberts, V.C., etc., dated June 24th, 1891.

the Bolan line shall be re-laid, and whether, if re-laid, it can be depended upon to serve as an alternative to the Harnai line if the latter becomes interrupted by floods or other causes. I am in favour of relaying the line because the Harnai Railway cannot be relied on with its single line to meet the pressure which the demands of a war with Afghanistan would put on our frontier railways. In 1886 I urged that the Bolan Railway should be remodelled between Hirok and Darwaza to avoid a break of gauge, and this was carried out. I think we are bound to keep up the Bolan line as a valuable accessory to the Harnai,[1] but I cannot too strongly urge upon the Government of India the necessity of constructing an alternative line quite independent of both the Harnai and Bolan railways. Two have been proposed—one from Karachi or Pasni[2] through Kharan[3] and Nushki[4] towards the Helmand,[5] and the other from the valley of the Indus near Bannu or Dera Ismail Khan through the Gomal and the Zhob to join the Harnai Railway not far from Quetta. In my opinion the latter alternative should be adopted. Sir James Browne and Major Scott estimate that within 2½ years of the commencement of the work an engine could be running over the Zhob route. I would suggest that the fullest financial liberty be given to Major Scott. We cannot go far wrong in pushing on the construction of the Zhob line and simultaneously with it the Kabul River Railway,[6] which in my opinion is of equal, if not greater, importance. . . . Simultaneously with breaks on the Harnai, the Bolan line has over and over again been obliterated (by floods). The only solution is to trust to neither line, but to construct an alternative independent of both." This opinion was supported by Browne in a memorandum written in September, 1891.[7] He said that he had studied the subject for 30 years and was convinced that a Zhob-Gomal line was strategically the best which could be made, and he added that it would entail only one rise and one fall to attain the Pishin plateau. But in spite of the strong advocacy of Roberts and Browne the Zhob-Gomal Railway was never built because a changed political situation did not justify heavy expenditure on a line which could not be otherwise than purely strategic for many years.

Although the construction of a 5′ 6″ gauge line, at a cost of at least 270 lakhs of rupees and probably more, could not be undertaken along the route surveyed by Scott, a plan was considered in later years to open up railway communication from Tank southwards to

[1] Nowadays the Harnai line is only an accessory of the Bolan, over which all heavy traffic moves if possible.
[2] On the coast about 470 miles west of Karachi.
[3] About 300 miles S.W. of Quetta.
[4] About 130 miles S.W. of Quetta.
[5] A river in south-western Afghanistan.
[6] Alluded to later in this chapter.
[7] *Note accepting the Zhob–Gomal route for a Railway from the Pishin Plateau to Upper India*, by Major-General Sir James Browne, K.C.S.I., C.B., dated September 23rd, 1891.

Fort Sandeman by means of a 2′ 6″ gauge line,[1] and in 1913 Major (now Colonel Sir Gordon) Hearn, R.E., reconnoitred this country. Three routes were available. One was by the Zhob and Gomal valleys where Scott had laboured; a second by the Chuhar Khel Dahana defile, south of the mighty mass of the Takht-i-Sulaiman; and a third through the Gat defile north of that mountain. It should be remarked here that Tank had already been joined to Kalabagh on the Indus by a 2′ 6″ gauge line built by Captain F. R. H. Eustace, R.E., and this could be extended easily to Murtaza, where the Gomal breaks into the plains.[2] Hearn and his party, which included Captain C. St. J. Lynch, R.E., covered nearly 600 miles between January 11th and April 16th, surveying and photographing as they went. "Lynch was far from well," says Hearn,[3] "and on one occasion having got an attack of malaria, begged to be left at a most inaccessible spot. However, I refused, and he made the next march on a camel, 'smoking' a thermometer, reading his temperature every hour or so, and surprised to find it falling steadily. As time went on the salts in the water caused a steady improvement in his health, and he finished up as fit as could be. A most cheerful and witty companion. He died at Quetta after the War, after serving under me once again."[4] Hearn's reconnaissances were valuable, but they have not yet resulted in a railway connection between Tank and Fort Sandeman, although the latter can be reached from the south by a 2′ 6″ gauge branch line from the Harnai Railway near Quetta.

Before leaving Baluchistan it may be well to mention the part taken by Royal Engineers in the survey and construction of a strategic railway which runs westwards from Spezand, south of Quetta, through Nushki to the vicinity of Duzdap, skirting the southern boundary of Afghanistan and finishing close to the Persian border. Lieut.-Colonel L. E. Hopkins, D.S.O., O.B.E., has had more concern with this Nushki Railway, and with railway reconnaissances in Persia, than any other Royal Engineer. "I joined the Nushki Railway under Mr. (afterwards Sir William) Johns in November, 1902," he writes,[5] "and with Lieutenant Cusack Walton, R.E., as my assistant, surveyed the Nushki Ghat or descent of 2,000 feet from the Quetta plateau to Nushki. . . . From November, 1903, I was in charge of the Nishpa tunnel through about half a mile of solid limestone, and of some 20 miles of line on each side of it. Cusack Walton did the next 30 miles south of me. The Nishpa tunnel is

[1] It is now recognized that nothing less than a 5′ 6″ gauge line is of much use for modern strategic purposes, but a 2′ 6″ gauge line is better than no line.

[2] A narrow-gauge line now runs south-westwards from Kalabagh by Isa Khel, Laki Marwat and Pezu to Tank and Kaur, and thence northwards to Manzai (east of Wana). A branch takes off northwards from Laki Marwat to Bannu.

[3] Notes sent to the author by Colonel Sir Gordon Hearn, C.I.E., D.S.O., late R.E., dated May 30th, 1933.

[4] On the Khaibar Railway Survey in 1919.

[5] Notes by Lieut.-Colonel L. E. Hopkins sent to the author on March 22nd, 1933.

over 6,000 feet above sea-level and the blizzards in winter are terrific. In the following July I was summoned to Simla in connection with the proposed Loi Shilman Railway near the Khaibar, but afterwards returned and practically completed the Nishpa tunnel before going back to Peshawar to start the Loi Shilman construction."

"In 1911," he continues, "a project for a Trans-Persian Railway was considered, and its preparation was allotted to Mr. W. Johns. We spent two years on that work and made a detailed survey of the whole length of the Mekran Coast from Karachi to Gabd, about 400 miles. I did the Pasni-Gabd section with Lieutenant J. A. P. B. Bowen, and Johns having joined us at Gabd, we explored the Sarbaz route to Bampur,[1] and on from there to Robat, and back to Quetta by the Nushki route. Altogether Bowen and I must have covered about 2,000 miles, mostly on riding camels with very little kit and a shelter-tent. The Mekrani himself travels a great deal, and especially to Western Australia, where he takes his camels for work in the deserts. At Pasni a wild Mekrani greeted me with the words 'Hello, Boss!' . . . When I returned to Persia in 1917 I found that the Nushki Railway had been extended to the Persian frontier, but a survey was needed to Duzdap and Neh.[2] This I carried out with a party of four civil engineers and a number of assistant engineers. We surveyed for some 300 miles through the usual wide, open Persian *damans* about 4,000 to 5,000 feet above the sea, and our men were struck and decimated by the terrible influenza epidemic of 1918. One officer died also."

Leaving the dreary and waterless uplands of Persia we now move across the map northwards and eastwards to the Kohat, Attock and Peshawar districts of the North-West Frontier, perhaps the most critical areas in an explosive line. A Royal Engineer who has done much railway work in these regions is Colonel S. L. Craster, C.B., C.I.E. As a Major he completed the building of the Mari-Attock line in 1898 and 1899, and laid the Nowshera-Dargai line between 1899 and 1901; and in 1900 and 1901 he surveyed and constructed the short line from Peshawar which leads to Jamrud near the foot of the Khaibar Pass, being assisted in this project by Lieutenant E. W. S. Mahon, R.E. Craster mentions[3] that when the Nowshera-Dargai line was opened to traffic early in 1901, the platforms were soon three feet deep in grain, although the line was then only on the 2′ 6″ gauge, and the inhabitants were clamouring for more room for their produce—a proof that even strategic lines may benefit trade and agriculture.

[1] About 150 miles inland to the north-west.

[2] In the Khorasan Province of Persia to the north.

[3] Letter from Colonel S. L. Craster to the author, dated August 10th, 1933. The Nowshera–Dargai line was converted later to 5′ 6″ gauge, thereby adding enormously to its strategic value; but even as a 2′ 6″ gauge line, its value was said to be greater than an additional brigade of troops.

The arrival of Lord Kitchener as Commander-in-Chief in 1902 heralded a boom in frontier railway schemes. Apart from work in the Khaibar region, a 2′ 6″ gauge line was completed in April, 1903, from Kohat to Thal, one of the Assistant Engineers being Lieutenant (now Major-General) A. Brough, R.E. There was a proposal in 1906 that this light railway should be converted to 5′ 6″ gauge and extended to Parachinar, and Hopkins, Bowen and a civil engineer surveyed the route; but unfortunately the project was shelved and the 2′ 6″ gauge alone connects Kohat and Thal at the present day. Afterwards, however, Hopkins carried out some interesting surveys for a system of 2′ 6″ gauge lines from Kohat to Bannu and Dera Ismail Khan, the section from Kohat to Bannu being done by Lieutenant R. N. Burn, R.E. This was a most difficult route, involving continual crossing and re-crossing of the Kurram. The Bannu-Thal railway has not been built, but Bannu can be reached by rail from the Kalabagh Bridge on the Indus by way of Laki Marwat, and Dera Ismail Khan is connected with Laki Marwat through Pezu and Tank. So much for the light railways of this region. We come at last to the problems of the most northern routes to Afghanistan through the Khaibar and other passes.

In 1885 the Panjdeh "incident" drew attention to the roads by which Russia might invade India. These were three in number—from Kandahar through Chaman on Quetta, from Ghazni through the Peiwar Pass and down the Kurram Valley to the Indus, and from Kabul through the Khaibar Pass on Peshawar. The existing railway facilities were quite inadequate for the lateral movement of our troops from one threatened area to another. No railway bridge spanned the Indus between Attock and Sukkur, a distance of more than 500 miles by river, and these places were not connected by any trans-Indus line. By 1889, however, the Harnai Railway had been taken far beyond Quetta and a fine cantilever bridge had been opened at Sukkur, so the situation in the southern area was much improved; but the central and northern areas of the frontier line caused anxiety to Lord Roberts and his Quartermaster-General, Sir James ("Buster") Browne, and particularly the northern zone around the Khaibar Pass. The caravan road up the Khaibar to Landi Kotal was judged to be incapable of carrying the heavy traffic needed to supply an army operating beyond the Khaibar against the Russians, while the construction of a railway was thought to be impossible because of the steep gradients and restricted space.[1] The most promising alternative seemed to be an extension of the railway across the Peshawar plain to the exit of the Kabul River from the moun-

[1] During the 2nd Afghan War of 1878–80, Mr. Guildford Molesworth had examined the possibility of taking a metre-gauge railway through the Khaibar Pass, but nothing came of the idea because of the constructional difficulties and the fact that railhead was then near Attock.

tains and thence up its right bank through the gorges which end some miles below Dakka in Afghanistan.[1]

Accordingly a railway survey expedition was despatched early in 1890 by Major-General Sir James Browne to ascend the gorge of the Kabul River, the leader of the party being Lieutenant (afterwards Major-General Sir) J. R. L. Macdonald, R.E., assisted by Lieutenant (afterwards Major-General Sir Philip) Twining, R.E., Lieutenant H. H. Austin, R.E., two infantry officers and 100 chain-men, with an escort of 200 men of the Khyber Rifles. The expedition set out on February 5th, and in 16 days surveyed a route for a railway from Peshawar to the entrance of the Kabul River gorge at Ursak, a distance of 16 miles, but the remaining 31 miles from Ursak to Samsai, near the "Durand Line," were not completed until May 4th. Beyond Samsai both banks of the river are in Afghanistan, into which the surveyors were forbidden to go, but they could view the country as far as Dakka, some eight miles distant. Macdonald reported that a line could be built with a ruling gradient as flat as 1 in 200, although 15 small tunnels and 40 bridges of medium spans would be required between Peshawar and Samsai. However, the attention of Government was transferred during the autumn to the Zhob Valley survey under Buchanan Scott, and for a number of years the Kabul Valley project was buried in the pigeonholes of Simla.[2]

In 1898, during the Afridi Campaign, advantage was taken of the military occupation of the Khaibar Pass to survey for a metre-gauge line as far as Landi Kotal. This work was entrusted to Captain S. L. Craster, R.E., assisted by Captain W. V. Scudamore and Lieutenants C. G. W. Hunter and E. Barnardiston, R.E. The very meagre escorts which were available were allotted to the actual surveyors or levellers, and the tribesmen were warned that any man or boy who appeared between a surveyor and his flag would be liable to be shot. This proved most effective. The work progressed rapidly and was finished in June. The alignment provided for a 2′ 6″ gauge line, but afterwards the possibilities of metre-gauge or 2′ 0″ gauge were considered. The ruling gradient in Craster's survey was 1 in 25, but according to Colonel Sir Gordon Hearn[3] the alignment had one disadvantage. It followed the southern edge of the Bagiari basin and was therefore too close to Zakka Khel country. On the grade adopted, it could not reach the more level ground near Shagai (Shahgai) except by another detour to the south, outside the basin. Such detours would have complicated the defence of the line. It

[1] Article entitled "The Kabul River Survey," by Brig.-General H. H. Austin, C.B., C.M.G., D.S.O., appearing in *The R.E. Journal*, Vol. XLI, March–Dec., 1927, pp. 414–426.

[2] The Kabul Valley route was fairly simple ; but it was long and the railway would be commanded completely from the left bank which was in Mohmand country, easily entered by an Afghan Army.

[3] Notes by Colonel Sir Gordon Hearn, C.I.E., D.S.O., late R.E., sent to the author on May 30th, 1933.

may be remarked that the existing 5′ 6″ gauge line follows quite another route, yet much of the information obtained in the 1898 survey was invaluable to its builders for the purpose of comparison. But the period of calm which succeeded the frontier turmoil of 1897–98 discouraged heavy expenditure on strategic lines, and Craster's survey for a railway up the Khaibar resulted in no actual construction. A Kitchener was needed to give the necessary impetus.

Lord Kitchener, soon after his arrival, concentrated on the railway communications along the North-West Frontier and towards Afghanistan. He did not like part of Macdonald's Kabul River alignment with its wide loop northwards, preferring to shorten it by a " cut-off " from Loi Shilman to Samsai, and he impressed this on Macdonald, who accompanied him over the route in 1903; and although he seemed at the time to be persuaded by Macdonald's arguments in favour of the original Kabul River alignment, he summoned Hopkins to Simla in July, 1904, and asked him if he would go out immediately to survey the Loi Shilman route. Hopkins, of course, consented, and with three R.E. subalterns[1] who were not railway officers carried out the work in the extreme heat of August and September. In the following year Hopkins began to lay the first section of the Loi Shilman Railway from Peshawar which was common to both the Loi Shilman and original Kabul River routes, and later handed over charge to Captain G. Lubbock, R.E., who had the assistance of Lieutenants Cusack Walton and C. F. Birney, R.E. Hopkins and Lieutenant R. N. Burn, R.E., then went on to the inner section of the alignment ending on the Afghan Frontier. Work continued steadily under Lubbock, but slowly, owing to labour difficulties, until Major-General Sir James Willcocks had crushed a Mohmand rising in May, 1908. It was then stopped for financial reasons, and in 1909 twenty miles of the most expensive line in the world were pulled up and the girders removed. So the Loi Shilman project ended in disappointment. The tunnels and formation alone remain for eight miles up the Kabul River gorge to mark a " Broken Road." With a strong and friendly Afghanistan under Amir Habibullah to the north, an expensive strategic railway was unnecessary in the days before the Great War.

However, the outbreak of the Third Afghan War in May, 1919, put a very different complexion on affairs. Immediate danger threatened, and the Government detailed Lieut.-Colonel G. R. Hearn, D.S.O., R.E., to reconnoitre a cart-road running through the country north of the Khaibar to Landi Kotal so that a light railway might be laid along the greater part of this road to save time. Two

[1] Lieutenants W. F. Maxwell, G. F. B. Gough and E. de L. Young, R.E. In 1905, Young did the survey for the duplication of the Khaibar Road between Bagiari and Ali Masjid and between Landi Kotal and Landi Khana, and these sections were practically finished when he left the Khaibar in 1907. More duplication was done during the Great War and after it. He surveyed for a road between Kam Shilman and Loi Shilman in 1906. This was re-surveyed and the road made later.

brigades had already occupied Dakka when Hearn motored through the Khaibar Pass in a whirling dust-storm to refresh his memory of its details, and afterwards obtained a small tribal escort and reconnoitred the Loi Shilman Valley. "The road from Jamrud," says he,[1] "does not enter the actual Khaibar Valley which runs much too close to the Bazar Valley just to the south and occupied by the Zakka Khel, the fiercest and most recalcitrant of the Afridis. A broad spur, almost a plateau, has to the east a pear-shaped basin draining to the plains near Bagiari. It was by the Bagiari and Shagai route that the road was constructed by a civil engineer, Mackeson, a relation of Colonel Mackeson, afterwards Commissioner of Peshawar and murdered there, and it was known as 'Mackeson's Road.' My staff were more familiar with the German General, *Mackensen*, and when camps and features were named after Mackeson they would persist in styling them by the German name! This road had been re-aligned and duplicated by 1919 right up to Ali Masjid,[2] which place had hardly been reached by the road when I saw it first in 1898. The road in the Bagiari basin twisted and turned on a grade of 1 in 13, with curves of 25 feet radius or less, and was therefore quite an unsuitable alignment for a railway. Nearly every spur fell sharply; but one, the Changai spur, maintained height for a considerable distance and attracted my attention. It seemed to have been made by Providence for the Khaibar Railway."

"From Landi Kotal," continues Hearn, "I proceeded by *tong* with a small tribal escort over the Haidari Kandao into the Kam Shilman Valley, which we left, at the junction with the Shilman cart-road, to enter the Loi Shilman Valley, afterwards returning for the night to the rest-bungalow in the Kam Shilman. My object in visiting the Loi Shilman was to see whether there was a better approach to the valley than by Hopkins' survey, which involved a viaduct 140 feet high over the Kam Shilman Valley and a very tortuous alignment beyond. I could not see any better alternative, and the severe grades necessary outweighed any advantage in shortening the distance by a 'cut-off.' The second day's journey got me back to Peshawar, several of the ponies limping and several rubber tyres cut to pieces. In my report I condemned any route in this direction. If a railway was to be made at all, the Khaibar route should be followed. Although it would be extremely difficult, and would involve reversing stations to reduce cost and a limiting gradient of 1 in 25, and although it would have to cross a summit 1,000 feet higher than by the Loi Shilman route, at least it would serve a certain peace-time traffic and could be extended with little difficulty. Also it would be only 36 miles in length instead of 54 miles by the river route.

[1] Notes by Colonel Sir Gordon Hearn, C.I.E., D.S.O., late R.E., sent to the author on May 30th, 1933.

[2] By Lieutenant E. de L. Young, R.E., and others, in 1905–07.

"My recommendation for a survey in the Khaibar Pass was accepted. An Engineer, Mr. A. J. Sleigh,[1] was sent to the Khaibar and a small staff collected, but the armistice with Afghanistan and the succeeding peace negotiations caused the breaking up of the party and my return to Simla. Shortly afterwards I was asked by the General Staff whether a broad-gauge (5′ 6″) railway through the Khaibar Pass was a practical possibility, and my reconnaissances enabled me to give the assurance, provided that reversing stations were permitted. To this there was no objection, and a survey was ordered not only through the Pass but beyond it to Sherabad. There was great urgency because our troops would be evacuating Afghan territory on September 15th, and we were already in the middle of August.

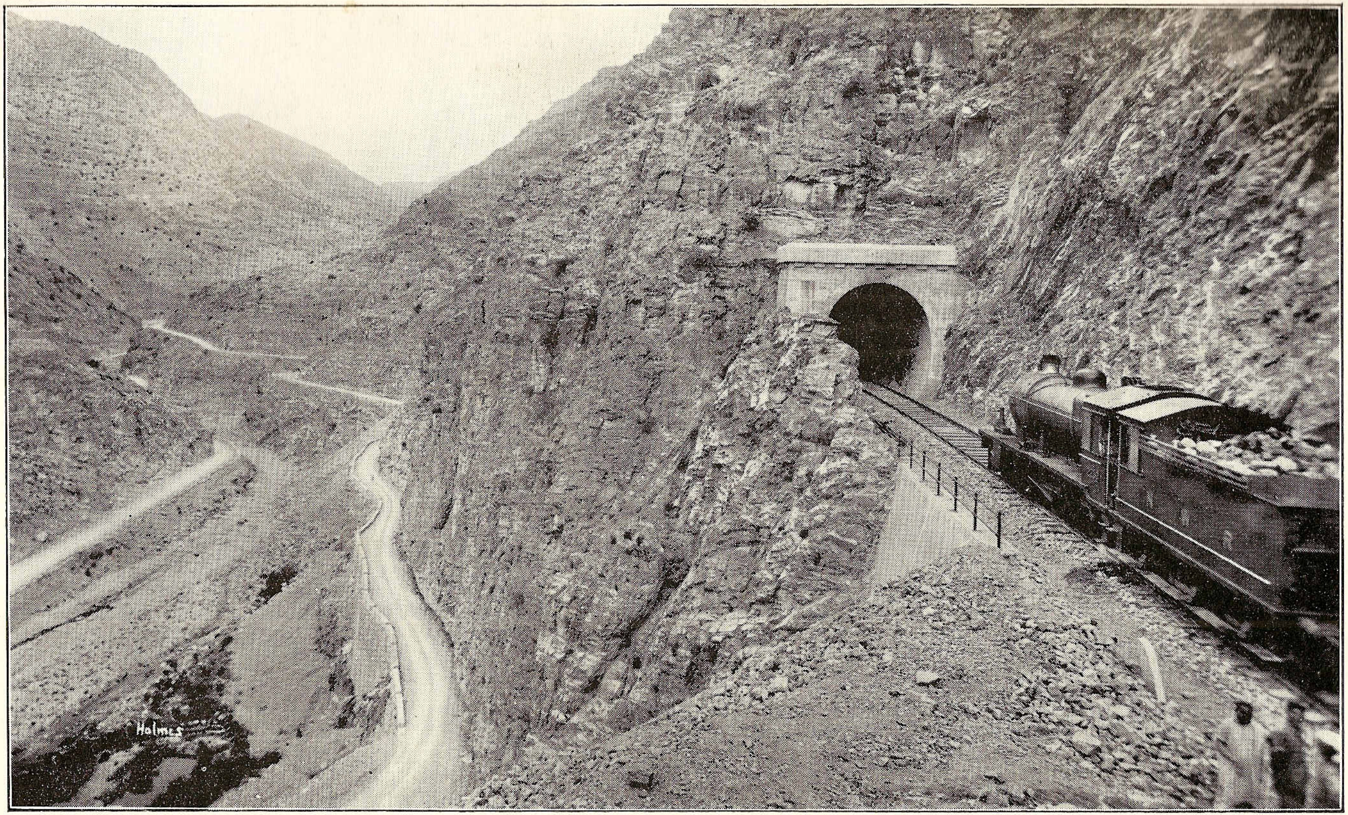
"One survey party was headed by Mr. Sleigh and the other by Major C. St. J. Lynch, D.S.O., R.E. Lieutenant J. E. Clutterbuck, R.E., joined Lynch's party from the Sappers and Miners at Dakka. While I had at this time a fairly clear idea of the probable alignment up to Landi Kotal, the descent to the Durand Line (the Afghan border) was not obvious.[2] The Landi Kotal Landi Khana section of the Khaibar Railway certainly presented great difficulties. The stream had several waterfalls, and both sides of the ravine were occupied by roads (grade 1 in 13) which could not be interfered with and must be kept open. Four level crossings were needed beyond Landi Kotal, and the station at that place had to be sited outside the protective towers but inside the outlying piquets. Previous experience had shown the desirability of making distance (and consequently fall) as quickly as possible to descend to easier ground, and I contemplated a complete 'spiral' near Michni Kandao; but subsequently I determined to keep high, skirting the steep basin which drains to Landi Khana and getting into the Tora Tigga *nullah*. A reversing station (which afterwards the Political Officer wanted to call 'Herne Hill') enabled the line to follow the general slope of this valley, and, by two short tunnels through spurs, to reach another reversing station at Landi Khana, whence the ground was easy to the frontier. Although the alignment adopted to Landi Khana was undoubtedly the least costly, it involved heavy work in these seven miles, including nearly 7,000 feet of tunnelling, a viaduct 85 feet in height, and many high banks.

"The section from Landi Kotal to Kata Kushta involved crossing and re-crossing the stream seven times[3] and a like number of crossings of the two roads (motor and cart). In the Ali Masjid Gorge,

[1] Superintendent of the Kalka–Simla Railway.

[2] The diagrams of the Khaibar Railway which appear opposite page 166 will assist the reader in following this description of the line and its survey and construction.

[3] Originally nine crossings were designed, but later two were eliminated.



ALI MASJID GORGE, KHAIBAR PASS.

where there are five tunnels, the line was located at a high altitude,[1] and practically on the level for about 7,000 feet, which, apart from other considerations, assists locomotives in hauling their loads against the gale which blows through the gorges on the Frontier during the spring.[2]

"The descent from Shagai to the plain was designed, of course, from the top downwards, making full use of the Changai spur. Originally I thought that one reversing station would suffice, and that the grade would work out; but when I arrived one day at the Shagai camp, Lynch met me with a very long face and said that the grade would not work out. I had all the contoured map sheets laid out and found, after two hours' work, that a second reversing station on the spur would solve the problem. The result is rather queer, for the alignment resembles a small 'w.' In a distance, as the crow flies, of $\frac{3}{4}$ mile, we were able to make a fall of 340 feet in $4\frac{1}{2}$ miles of railway. This is 'development' with a vengeance![3] Between Shagai and Bagiari Stations, nine tunnels aggregating 3,963 feet were needed. One retaining wall was 64 feet high, and one viaduct (five spans of 40-feet girders) was over 50 feet high. Still there was no 'heroic' work in this section such as on the Louise Margaret Bridge in the Chappar Rift on the Harnai Railway."

A peculiarity of the Khaibar Railway is that it is so inconspicuous. A traveller by the motor-road rarely notices it. The line is perpetually vanishing into the hillside to reappear in the most unexpected places. Sometimes it seems to be lost entirely, and from Michni Kandao down to Landi Khana near the Afghan border hardly a vestige of the railway can be seen. The explanation lies in the clever manner in which Hearn took advantage of every spur and valley to gain height in the ascent and lose it in the descent, yet allowing for an adhesion line of the full 5′ 6″ gauge. The gradients, it is true, are exceptionally severe, but the line is laid with curves which are far less abrupt than those which caused so much trouble on the Harnai Railway.[4] Every opportunity was taken to reduce the amount of bridging by the diversion of streams where possible, and the most rigid economist could not complain of waste.

The survey work was completed by the two parties early in December, 1919, forty miles of difficult railway having been located on paper in about four months, and the preparation of plans and

[1] It was decided to take the line through the gorge 100 feet or more above the roads, and to drop steeply to Shagai. Interference was thus avoided with the roads and with the aerial ropeway which ran through the gorge during the building of the railway.

[2] The gale is said to be due to cold air pouring down to replace the heated air rising from the plains.

[3] The development to Landi Khana makes $3\frac{1}{2}$ miles of railway where the fall in 4/5ths of a mile (as the crow flies) is 577 feet.

[4] A lesson had been learnt also from the Simla–Kalka line completed in 1903. The sharp curves on this metre-gauge railway produced terrible wear in the rails and wheels.

estimates was taken in hand. But a hitch then occurred. Brigadier-General Sir W. Danvers Waghorn, C.B., C.M.G., late R.E., records what happened.[1] "On my appointment to the Railway Board at the end of 1919," he writes, "I found that the Government of India were considering a recommendation of the Board for the construction of a Khaibar Railway, but the recommendation envisaged a 3′ 6″ gauge line. I went at once to Sir Arthur Anderson, the President of the Railway Board, and told him I could not be a party to the recommendation. The 3′ 6″ gauge had been proposed on the ground of rapidity of construction. A 2′ 6″ gauge, indeed, had been pressed for in certain quarters, but the Railway Board had ruled this out as too light, and, to accelerate construction, proposed to build certain heavy gradients of the 3′ 6″ gauge line on the rack system. I said to Sir Arthur, 'Why not introduce the rack system for an extension on the 5′ 6″ gauge?' He replied that it had never been done on so wide a gauge, and I then suggested wiring to the Consulting Engineers at home as to the feasibility. This was done, and a reply came that a 5′ 6″ gauge rack was feasible."

Hearn had already been called to the headquarters of the Government to discuss the matter. He had pointed out that the capacity of the railway would certainly be lessened if trains could only travel at four miles an hour, as on the Nilgiri Railway, and also that no broad-gauge railway had ever been constructed on the rack system.[2] He had added that it was doubtful whether the rack and brakes for a broad-gauge line would be sufficiently strong, and that a special type of locomotive was objectionable. As the Consulting Engineer to the Government of India was very guarded in his opinion, the proposal for a rack railway was dropped, but not before Lieutenant W. Macrae, R.E., who had joined Hearn's staff, had been obliged to re-survey the Landi Khana gorge and basin for a new alignment which was never required. The possibility of using electric instead of steam traction was also considered, as it was thought that steeper gradients with electric traction might enable the engineers to dispense with the two reversing stations between Bagiari and Shagai and perhaps with those beyond Landi Kotal; but the cost of providing and maintaining sufficient electrical power-plant and rolling-stock to deal with the emergency of war negatived this suggestion.

Earthwork was begun at Landi Kotal in December, 1920, in Shinwari territory, to test the attitude of the tribes towards railway-construction, and to gain experience about rates.[3] A few contractors

[1] Letter from Brig.-General Sir W. Danvers Waghorn to the author, dated May 26th, 1933.

[2] The Nilgiri Railway, parts of which are on the rack system, is a metre-gauge line.

[3] Article entitled "The Khyber Railway," by Mr. V. Bayley, C.I.E., appearing in the *Minutes of the Proceedings of the Institution of Civil Engineers*, Vol. 222, 1925–26, Part 2, Paper No. 4588, p. 10.

were nominated by the Political Agent, and negotiations began. The first contractors incurred much unpopularity, and had sometimes to fight to retain their work. A few, indeed, were murdered. The railway had to be constructed through the agency and in the territory of savage tribes regarded with terror by the skilled workmen it was desired to import, fiercely jealous of their traditional rights, and to some extent hostile to the whole project, so all officers, subordinates, works establishment and imported skilled labourers were housed each night in British fortified posts along the alignment, and distributed each morning, and collected each evening, by motor-lorries. Thirteen labour camps were built for the local labourers, and defended by posts on the neighbouring heights held by *khassadars*[1] who also guarded the whole line during the day. It was said that they not only picketed the heights and kept a look-out for raiders, but also watched each other! The system was satisfactory, and work progressed steadily, even though its quality was often not all that it should be because the labourers were more expert with the rifle than the spade, drill and trowel. But the strain on the staff was most severe. Several failed under it and had to be relieved of their duties. Only those with nerves of iron could endure it for long.

A large amount of blasting was necessary. According to Hearn, more than 100 tons of high explosive were expended.[2] There were very few accidents, and the tribesmen have a right to be proud of the energy which they showed and the manner in which they fulfilled their agreements. An excellent Mechanical Division was formed under Captain E. F. Johnston, R.E., to maintain the plant and to manage a fleet of Fiat lorries and "Sentinel" steam-wagons. Drilling in the numerous tunnels was done with jack-hammers, the compressed air for which was supplied by portable petrol-driven air-compressors hauled up the mountain slopes. Concrete mixers and concrete block-making machines were employed, and steel shuttering for retaining and other walls. Altogether the construction of the Khaibar Railway, at a cost of about £2,000,000, was carried out under the most approved methods.

Hearn remained in charge of the undertaking until he was transferred to the Eastern Bengal Railway as Chief Engineer in November, 1922, when Major E. P. Anderson, D.S.O., R.E., became Superintendent of Works in the Khaibar. Anderson had had varied constructional experience on Indian railways since he came to the country in 1903 as the first R.E. officer who had received mechanical training in

[1] Armed guards of friendly tribesmen, under the Political Officer. They provided their own rifles.

[2] Article entitled "The Survey and Construction of the Khyber Railway," by Colonel Gordon Risley Hearn, C.I.E., D.S.O., R.E., appearing in the *Minutes of the Proceedings of the Institution of Civil Engineers*, Vol. 222, 1925–26, Part 2, Paper No. 4,590, p. 40.

England,[1] and during part of the Great War he had been Railway Construction Engineer with the Fourth Army in France. He was a worthy successor to Hearn. Under him were Mr. V. Bayley in charge of one constructional division[2] and Captain J. R. Roberts, R.E., in charge of another, each with a staff of engineers and subordinates, and he carried on the work most successfully until he was transferred elsewhere in February, 1924, after handing over charge to Bayley. It is sad to relate that the latter broke down in health after five years' continuous work, just before the Khaibar Railway was opened as far as Landi Kotal with great ceremony on November 2nd, 1925. Not long afterwards it was opened to Landi Khana. It is no longer necessary to go armed and escorted through the Pass in daylight, for the railway has had a wonderful effect in civilizing the Khaibar region and in encouraging friendly relations with the neighbouring tribes by the quick and easy transit which it affords and the steady employment which it gives.[3]

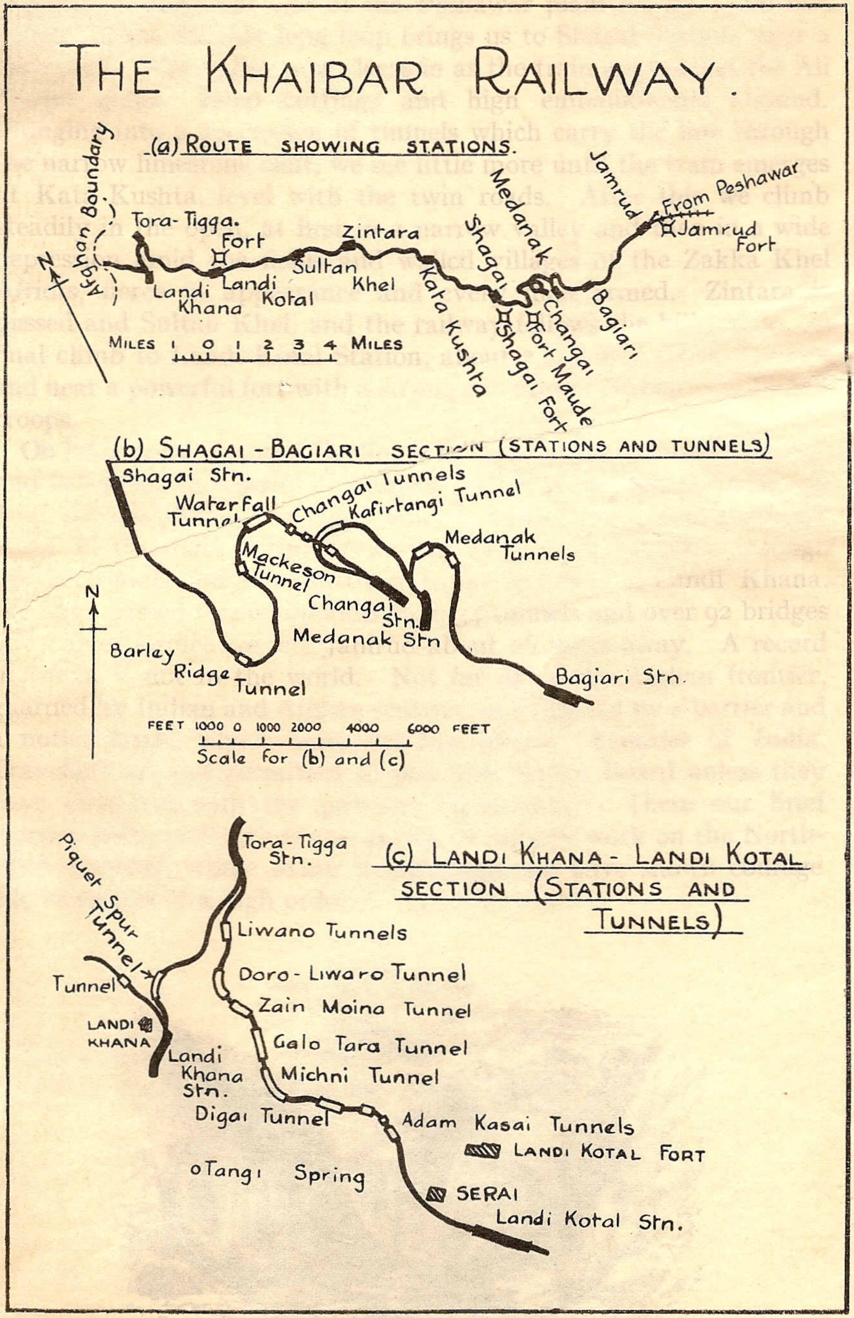
If we travel over the completed line we climb a steadily increasing grade from Jamrud towards the mouth of the Pass. Bagiari Station lies in its jaws, and ahead are steep hillsides up which the railway must find its way, while on the skyline, far above, is the fortified reversing station at Changai which can be reached only by traversing three miles of winding track. After passing Bagiari a high bridge carries the railway over the valley in which lie both motor and caravan roads, and from this bridge can be seen two reversing stations, Changai and another below it. Impossible though it seems, both belong to the same railway, and a long ascending curve through two tunnels brings us to the first of the two—Medanak. Next, the train climbs a *nullah* to the mouth of the Kafirtangi Tunnel, and we emerge to a fine view of the valley and the forts which guard the Pass.

The train reaches Changai, and after reversing, follows a loop round the head of the valley through a series of tunnels until it meets

[1] He was soon followed by Lieutenants C. S. M. C. Watson, E. St. G. Kirke and C. E. Colbeck, R.E., and all joined the Locomotive Branch, but none remained in it for long. As early as 1888, however, Lieutenant (afterwards Major-General Sir) P. G. Twining, R.E., a Canadian from Kingston College, Canada, with practical experience on the C.P. Railway, including locomotive work, had joined the Locomotive Department, N.W. Railway, and remained in it for a year or two. He achieved wonders in the repair of engines and rolling-stock with the British Field Force in China in 1901–02.

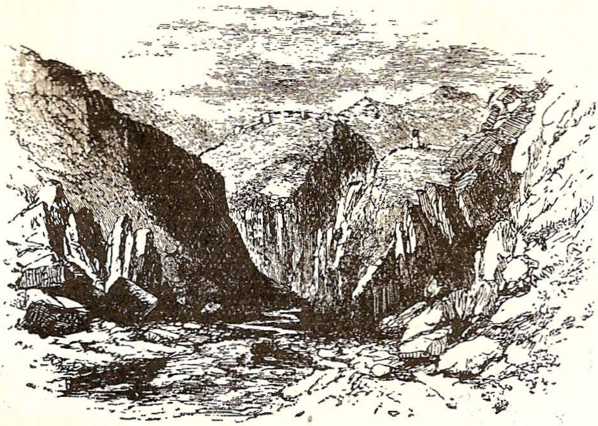
[2] See *Permanent Way through the Khyber*, by Victor Bayley, C.I.E., C.B.E. (1934).

[3] Technical details of the Khaibar Railway are given in an article entitled "The Khyber Railway," reprinted from *The Railway Gazette* of September 17th, 1923, and appearing in *The R.E. Journal*, Vol. XXXVIII, March–Dec., 1924, pp. 271–276. The line—a single adhesion one of 5′ 6″ gauge—runs from Jamrud (1,496 feet above M.S.L.) through Landi Kotal (3,495 feet) to Landi Khana (2,622 feet), a distance of 26·13 miles. Including a further length of formation laid to the Afghan frontier the total length is 27¾ miles. The ruling gradient from Jamrud to Shagai is 1 in 33·33, from Shagai to Landi Kotal 1 in 40 (except in one short length), and from Landi Kotal down to Landi Khana, 1 in 25. There are 2·55 miles of tunnels, none exceeding 1,400 feet in length; two lofty viaducts, 80 feet and 55 feet high; and a large number of bridges and culverts, but none of very great size. The sharpest curve is seven degrees (818·51 feet radius), for Hearn refused to have any curve of less than 800 feet radius. The rails are flat-footed on deodar sleepers, with bearing-plates and dog-spikes.


THE KHAIBAR RAILWAY.
(a) ROUTE SHOWING STATIONS.
Afghan Boundary
N
Tora-Tigga.
Fort
Zintara
Sultan
Khel
Landi Khana
Landi Kotal
Kata Kushta
Shagai
Shagai Fort
Medanak
Changai
Fort Maude
Bagiari
Jamrud
Jamrud Fort
From Peshawar
MILES 1 0 1 2 3 4 MILES
(b) SHAGAI - BAGIARI SECTION (STATIONS AND TUNNELS)
Shagai Stn.
Waterfall Tunnel
Changai Tunnels
Kafirtangi Tunnel
Medanak Tunnels
Mackeson Tunnel
Changai Stn.
Medanak Stn
N
Barley Ridge Tunnel
Bagiari Stn.
FEET 1000 0 1000 2000 4000 6000 FEET
Scale for (b) and (c)
(c) LANDI KHANA - LANDI KOTAL SECTION (STATIONS AND TUNNELS)
Tora-Tigga Stn.
Piquet Spur Tunnel
Tunnel
Liwano Tunnels
Doro-Liwaro Tunnel
Zain Moina Tunnel
Galo Tara Tunnel
Michni Tunnel
LANDI KHANA
Landi Khana Stn.
Digai Tunnel
Adam Kasai Tunnels
LANDI KOTAL FORT
Tangi Spring
SERAI
Landi Kotal Stn.

the roads again close below Fort Maude. At times we get fleeting glimpses of the Pass and of the Peshawar plain nearly 1,000 feet below. Then another long loop brings us to Shagai Station, near a large fort. The valley now closes in as the train approaches the Ali Masjid gorge. Deep cuttings and high embankments abound. Plunging into a succession of tunnels which carry the line through the narrow limestone cleft, we see little more until the train emerges at Kata Kushta, level with the twin roads. After this we climb steadily in the open, at first in a narrow valley and then in a wide depression amid the fields and walled villages of the Zakka Khel Afridis, fierce in appearance and every man armed. Zintara is passed and Sultan Khel, and the railway follows the hillside on its final climb to Landi Kotal Station, about 2,000 feet above Jamrud and near a powerful fort with a strong garrison of British and Indian troops.

On leaving this summit the line falls rapidly, passes a caravanserai, and enters another series of tunnels. Then it burrows through still more tunnels up the Tora Tigga valley to a reversing station and back again to the main basin, descending steeply all the time, through another tunnel and more cuttings, to the terminus at Landi Khana. We have passed through no less than 34 tunnels and over 92 bridges and culverts since we left Jamrud about 26 miles away. A record in India, if not in the world. Not far off is the Afghan frontier, guarded by Indian and Afghan sentries, and marked by a barrier and a notice board which bears the inscription "Frontier of India. Travellers are not permitted to pass this Notice Board unless they have complied with the passport regulations." There our brief journey ends, and with it this sketch of railway work on the North-West Frontier, where many Royal Engineers have shown courage and initiative of a high order.



FORT OF ALI MUSJID, IN THE KHYBER PASS.

CHAPTER X.

MARINE WORKS.

ALTHOUGH India has thousands of miles of coastline, there is hardly a country which is so deficient in harbours for the accommodation of large ships. During the south-west monsoon, the western littoral is pounded by heavy seas, and coastal navigation almost ceases. At other seasons, foreign trade is carried on from only a few ports on that coast, and mostly from Bombay and Karachi, which are always open. Along the eastern coast, except at Chittagong, there is a complete absence of proper natural shelter for shipping. Harbours have been made at Madras and Vizagapatam ; but elsewhere the coast is almost unapproachable by any steamer with a deep draught. Burma, on the other hand, has good harbours at Akyab, Bassein on the Irrawaddy, Rangoon on a branch of the same river, and Moulmein.

In the north-east of India is the port of Calcutta, far up the treacherous channel of the Hugli, yet with the bulk of the foreign trade until the Suez Canal was opened in 1869. When ships no longer voyaged round the Cape, or plied as ferries between Bombay and Suez, and when the trunk lines of railway had been extended across the Indian peninsula, commerce developed rapidly through Bombay and the newer port of Karachi, and Western India came into its own. Burma, a modern acquisition, naturally lagged behind until the petroleum and other industries brought Rangoon into prominence. Yet there can be little doubt that, trade being the life-blood of the East India Company, the Directors recognized at a very early date the importance of proper harbour and dock accommodation for their shipping, and as their fleets increased, the need also for the lighting of certain parts of the coast. Their marine works included the reclamation of large areas of land from the sea in making Bombay, the construction of some docks and wharves at Bombay, and Calcutta, and the provision of one or two primitive lights here and there. Apart from some marine surveying, they were too busy with internal communications to devote much attention to the demands of shipping, and consequently the proper lighting of the coasts was not undertaken until some years after the Indian Mutiny when control had been transferred to the Crown.

The marine employment with which military engineers in India have been most closely concerned is the construction of lighthouses, and

this is curious because civil engineers were flocking into the country before such work was taken seriously in hand. The explanation, however, is that India once possessed an enthusiast in this line in the person of Lieut.-Colonel Alexander Fraser, C.B., R.(B.)E., who devoted himself heart and soul to the lighting of the Burmese coast in particular, and whose mantle descended on other officers of his Corps. Fraser entered the Bengal Engineers from Addiscombe in 1843 and served in both the Sikh Wars and in the Second Burma War of 1852, and a few years later he carried out his most conspicuous work on the coast of Burma. Afterwards he was a Chief Engineer in the Public Works Department, North-West Provinces, from 1873 to 1879, and a Member of the Viceroy's Council for a few months in 1880. He retired as a General in 1887, and died in 1898.[1] Other Royal Engineers worked under him, or followed in his footsteps, and thus the Corps has had an intimate connection with lighthouse work extending almost to the present day.

It is necessary to go back many years to trace the beginnings of marine work by the East India Company's engineers, a work which began with the construction of piers and docks. The suggestion that a pier should be built at Madras came from Warren Hastings[2] in 1770. Docks and piers had been provided already at Bombay and Calcutta, but such luxuries were not yet sanctioned for the unprotected shores of the "benighted Presidency." Hastings wrote to his brother-in-law, Mr. Woodman :—[3] "I have conceived it possible to carry out a Causeway or pier into the Sea beyond the Surf. I have heard that the Surf at Margate is as great as that on this Coast. There, such a pier has been constructed. I have sent enclosed the Proposition for such a Work which I beg the favour of you to show to Mr. Brindley and desire his opinion. I should be obliged to you if you would obtain the opinion also of Mr. Smeaton[4] or Mr. Mylne upon it. I believe it is usual to consult these people upon subjects of this kind and to fee them for it, because I recollect an Advertisement of Smeaton's to this purpose." Woodman replied at great length, and sent plans of Ramsgate Harbour, but before any action could be taken, Hastings sailed for Calcutta early in 1772. Ten years later, the Governor, Mr. Alexander Davidson, wrote[5] "The grand Object at Madras ought to be a Pier. Mr. Ritchie[6] is said not to be unacquainted with this Branch of Masonary and I have no doubt but a permanent Pier might be built. If this, by Encouragement, could be effected, Fort St. George would undoubtedly become the

[1] The author has been privileged to see the typescript of a very interesting, but hitherto unpublished, account by General Fraser of his boyhood and his career in India, including both his war and civil engineering services. This is in the possession of his relatives.

[2] Hastings was then Second Member of the Madras Council.

[3] *Hastings Papers*, Vol. I, April 7th, 1770.

[4] The builder of the third Eddystone Lighthouse, completed in 1759.

[5] *Madras Public Consultations*, Vol. CXXXVIII, November 22nd, 1782.

[6] A Marine Surveyor.

greatest Port of delivery in the East Indies." Still, the "grand object" remained, for many years, in the realms of fancy.

Then, in 1786, came an astounding effusion from that eloquent amateur engineer, Captain George Baker,[1] some extracts from which may be quoted.[2] "If I may hereafter be able to Reduce the Whole (scheme) to a Tolerable Clear Statement," wrote he, "I shall not Scruple to Submit it to the Discerning Eye and Better Judgement of this Government. But this with all that Diffidence, Defference and Respect due from an Unlettered and Unscientifick Man Appearing before such Solemn Tribunals. . . . I leave a Jetty, Pier or any other work of whatever Denomination of Solid Masonry, or of Piers of Masonry, to the Consideration of those who may be Better Judges, and Suppose for the Present that the Work which I have Hinted at were a Construction of Wooden or other Piles on which to lay a Pipe from the Beach to the Back of the Surf for Delivering the water there." But even this humble and modest appeal met with no response. However, after an interval of 12 years, Captain W. C. Lennon, M.E., not only revived the schemes of Hastings and Davidson for building a proper pier at Madras, but proposed to make a closed harbour.[3] Lennon's pier was to be 450 yards long, of solid masonry, 30 feet wide at the top, and suitable for development later into a harbour. He estimated that it would cost £120,000; but if a closed harbour was preferred at the outset it should project at least 650 yards and would cost £450,000. Again nothing came of the Madras pier or harbour schemes, and it was not until the middle of the nineteenth century that a screw-pile pier more than 300 yards long was built seawards. Nevertheless small harbour works were executed by the Company's engineers, towards the end of the eighteenth century, at some ports on the East Coast, one of which, Masulipatam, was greatly improved in 1794 by Mr. Michael Topping, the Astronomer of Madras—a curious instance of the ubiquity of engineering talent in those far-off days.

Between 1835 and 1837 much ink was expended on the subject of a breakwater at Madras.[4] A sea-wall, known as the "Bulwark," had been built some years earlier by that keen reformer, Lieut.-Colonel T. F. De Havilland, M.E.,[5] and had proved satisfactory in shielding the Black Town shore from damage, so Captain (afterwards Colonel Sir Arthur) Cotton, M.E., entered with gusto into a discussion with a "Breakwater Committee" about the possibility of building a stone breakwater outside the outer line of surf and parallel to the

[1] Late Master-Attendant.

[2] *Madras Public Consultations*, Vol. CXL, November 10th, 1786. See also Chapter III, pp. 37, 38.

[3] *Madras Public Consultations*, Vol. CCXXVII, July 6th, 1798.

[4] *Reports on various Professional Subjects connected with the duties of the Corps of Engineers, Madras Presidency*, by Captain J. T. Smith, M.E., Vol. I, 3rd edition, 1859, pp. 1–12.

[5] See Vol. I, Chapter XIII, p. 228.

GENERAL ALEXANDER FRASER, C.B., LATE ROYAL (BENGAL) ENGINEERS.

shore. Although De Havilland wrote some advice from Guernsey, the breakwater was never built.

In 1868 the Madras Government appointed another Breakwater Committee to suggest possible improvements. "As far as facilities for trade are concerned," wrote the Committee in January, 1869, "the Port of Madras at the present time differs very little from what it was nearly 250 years ago, when, as a small fishing village, it first attracted attention. It remains an open roadstead, destitute of any natural shelter." They asserted that the choice lay between a breakwater detached from, and parallel to, the shore or a closed harbour formed by two piers running out into deep water. They preferred the latter, but feared that accumulation of sand would render it impossible, and they then invited the opinions of two retired military engineers who were eminent in irrigation work—Colonels Sir Arthur Cotton and C. A. Orr, late of the Madras Engineers. Orr agreed with the Committee, but Cotton preferred a breakwater, although he did not think that a harbour would silt up.[1] In the end, the harbour scheme triumphed. Mr. William Parkes, an experienced harbour engineer, submitted a project in 1872 for a closed harbour formed of two piers each about 1,200 yards long and 1,000 yards apart, connected by a breakwater with an opening 150 yards wide. His first estimate amounted to £565,000, but this was increased later to £776,000. The project was sanctioned and work began in 1876, the foundation stone having been laid in the previous year by H.R.H. The Prince of Wales (afterwards King Edward VII.). By the end of 1881 the harbour was practically finished, but a cyclone then wrecked it so seriously that a sum of £459,000 was afterwards spent on repairs, so that the Madras Harbour actually cost nearly $1\frac{1}{4}$ millions sterling.[2] It has been greatly improved during the present century, but military engineers have had no part in the work which was executed mainly under the late Sir Francis Spring, K.C.I.E.[3] As in irrigation, buildings, roads and railways, soldiers were the pioneers in marine works. They filled the breach until civilian experts arrived.

On the western coast of India are several small ports in which harbour works were executed by the Company's engineers. The chief interest, however, centres in Bombay, a city blessed with one of the finest and largest natural harbours in the world. "Bombay Harbour presents one of the most splendid landscapes imaginable," says a writer in the *Asiatic Journal* in 1838. "The voyager visiting India for the first time, on nearing the superb amphitheatre, whose wood-crowned heights and rocky terraces, bright promontories and

[1] *Report on the Formation of a Harbour at Madras*, by Mr. W. Parkes, dated November 4th, 1873. Cotton had experimented with groynes on the beach at Vizagapatam.

[2] *Ways and Works in India*, by G. W. MacGeorge, p. 518.

[3] Sir Francis Spring, K.C.I.E., for many years Chairman and Chief Engineer of the Madras Port Trust, died in August, 1933.

gem-like islands are reflected in the broad blue sea, experiences none of the disappointment which is felt by all lovers of the picturesque on approaching the low, flat coast of Bengal, with its stunted jungle. A heavy line of hills forms a beautiful outline upon the bright and sunny sky; foliage of the richest hues clothes the sides and summits of these towering eminences; while below, the fortress intermingles with fine trees, and the wharves running out to the sea present an imposing spectacle on which the eye delights to dwell." A bitter critic once said that the finest view in India was that of the Bombay light disappearing below the eastern horizon. Fortunately, most of our countrymen disagree with him. They prefer to remember their first view—a vast harbour, framed by the distant Ghats, in every way a fitting gateway to our greatest Eastern possession.

As the hand of God had fashioned the wide reaches of Bombay Harbour, the hand of man had merely to adapt them for shipping. Accordingly, in 1686, a few years after Bombay was acquired, the Council asked for a dry dock. Three years later, their request was sanctioned by the Directors, but there the matter seems to have ended. Until 1735 the British built their ships at Surat, their original settlement north of Bombay. Then they induced a *Wadia* or Parsi shipbuilder of Surat named Lavji Nasarvanji to migrate southwards, and he and his descendants were, for many years, the masterbuilders of ships and docks in Bombay.[1] At first, Lavji Nasarvanji was content to use as a dock an open mud basin[2] in which the tide ebbed and flowed; but in 1748 he set to work to make a proper dry dock, 209 feet long, 47 feet wide and 15 feet deep, and finished it in 1750. Twelve years later he built a second dock, and a third was completed in 1766, when the dockyard was described as "the pride of Bombay and the astonishment of travellers."

The first appearance of military engineers in the Bombay Dockyard seems to have been early in the nineteenth century, when the building of a new dry dock parallel to the three old ones was entrusted to Captain-Lieutenant R. B. Crozier of the Bombay Engineers. Crozier began the work in 1805, but he was soon replaced by a brother officer of the Bombay Corps, Captain William Cowper, and by the beginning of 1808, in spite of the hardness of the rock, difficulties with tides and a lack of trained workmen, Cowper had completed the first of two new dry docks with sides of fine cut stone and a bottom of solid masonry.[3] Shortly before the dock was finished, the building of the *Minden*, a 74-gun ship, was begun in it, and the *Bombay Courier* came out with the patriotic sentiment "May the ever-enduring Indian teak, under the auspices of our gallant tars,

[1] *The Rise of Bombay*, by S. M. Edwardes, p. 163. The largest of hundreds of teakwood sailing ships launched in Bombay was the *Ganges*, a frigate of 2,289 tons.

[2] Situated about the centre of the present Government Dockyard.

[3] This dock was 286 feet long, 63 feet wide and 23 feet deep.

rival the glories of the British oak."[1] Cowper had the second dock ready for use on June 23rd, 1810. It was widened and improved in 1841, and between 1843 and 1847 Captain J. Estridge, Bo.E., carried out similar work on the original of these two "Duncan" docks.[2]

Two dry docks were constructed between 1845 and 1867 for the Peninsular and Oriental and the British India Steam Navigation Companies; but wet-dock accommodation was still lacking, and it was not till 1875 that the Sassoon Company opened Bombay's first small wet dock at Colaba. This was the forerunner of many fine works. Prince's Dock, designed by Mr. T. Ormiston, was begun in 1875, when the first stone was laid by H.R.H. the Prince of Wales, and was opened in 1880. The Victoria Dock was opened in 1895, and the Alexandra Dock, with an area of nearly 50 acres and a maximum depth of 36 feet, was completed in 1914; but these were all the work of civil engineers. In 1886, however, Colonel H. D. Olivier, R.E., received the thanks of Government for designing a graving dock for Bombay Harbour, and in 1890 Captain G. M. Porter, R.E., prepared a design for the construction of a wet basin and the extension of some docks at a cost of more than Rs. 16 lakhs. These tasks, and the opening of a "Merewether Dry Dock" in 1891 to commemorate Colonel G. L. C. Merewether, late of the Bombay Engineers and a former Chairman of the Port Trust, who did excellent work in Bombay Harbour during the 'eighties, show that the connection of military engineers with marine enterprises on the western coast lasted nearly to the end of the nineteenth century.

Harbour defences at Bombay and other Indian ports have naturally occupied the time of many military engineers, but they hardly come within the scope of this volume; yet the excellent work of Captain W. H. Pierson, R.E., when Secretary of the Indian Defence Committee from 1877 to 1880 should not be overlooked, for he was largely instrumental in securing the proper fortification not only of Bombay but also of Karachi, Aden and Rangoon. Major-General (afterwards General) Sir George Chesney, C.S.I., C.I.E., late R.E., was also conspicuous in this work. From the time he became head of the Indian War Department and a member of the Viceroy's Council in 1886, to the date of his departure from India in 1891, he devoted much attention to the defences of Indian ports and brought them almost to completion.[3] The true foundations of the present systems

[1] *Gazetteer of Bombay City and Island* (1910), Vol. III, p. 269, footnote. Bombay was the first Eastern dockyard to produce a 74-gun ship. As regards steam vessels it is interesting to note that the first steamship to run to India was the *Enterprise* (500 tons), which sailed from Falmouth with 17 passengers on August 16th, 1825, and reached Calcutta *via* the Cape in 113 days. The *Hugh Lindsay* was the first steamship to operate in Bombay waters. She sailed from Bombay for Suez on March 20th, 1830.

[2] So called after Mr. Jonathan Duncan, Governor of Bombay.

[3] The batteries at Bombay, Karachi and Aden were remodelled and re-armed between 1885 and 1887 under the direction of Major-General (afterwards General) W. W. Goodfellow, C.B., late R.E.

of defence may be ascribed to him, although these systems have been greatly altered since his day.

Bombay is largely a city of reclamations, and the present Bombay Island was formed by linking together seven small tracts of land separated by the sea at high tide. Causeways were made, " drowned lands " were reclaimed from the sea and cultivated, breaches were filled in gradually, and thus the modern island was built up. No serious attempt was made to check the inroads of the sea until the Hornby Vellard[1] was constructed on the west coast between Mahalakshmi and Warli during the Governorship of Mr. William Hornby (1771–1784), although a certain Captain Bates had attempted some reclamation work in this area between 1720 and 1727, but the success of the Hornby Vellard led to other works in which military engineers were prominent. As mentioned in Chapter V, Captain W. Brooks, Bo.E., made a causeway at Sion, between 1798 and 1805, to connect Bombay Island with Salsette, and this was enlarged by Captain W. A. Tate, Bo.E., in 1826. Seventeen years later, Lieutenant A. Crawford, of the Bombay Infantry, designed a causeway at Mahim, which was constructed soon afterwards by Captain J. J. F. Cruickshank, Bo.E. Meanwhile a causeway had been laid in 1838 connecting Colaba and Old Woman's Island with Bombay—a notable work by Lieut.-Colonel G. R. Jervis, Bo.E., which was widened and rebuilt in 1861–63. When Jervis had completed this causeway, Mrs. Postans wrote :—[2] " Colabah is a pretty retired spot. . . . A rocky sort of way connected this tongue of land with Bombay, which at high tide was covered with the rolling flood. Many have been the luckless wights who, returning from a festive meeting, have found the curling waves beating over their homeward path. The more impetuous have sought to swim their horses across this dangerous pass, and lives have been lost in the attempt. This inconvenience led at length to the erection of a solid and handsome *vallade*, with a footpath protecting the elevated and level road." But land reclamation work passed out of the province of the military engineer in Bombay during the last half of the nineteenth century, and the only instance of its revival occurs after the Great War, when a Royal Engineer, Major Sir H. A. Lawless Hepper, became Director of Development in charge of many enterprises, including a Back Bay Reclamation Scheme which has not yet been completed.[3] It may be mentioned here that the extensive works undertaken by the Bombay Improvement Trust, as part of the general programme, were ably executed for several years by Major T. R. Sneyd-Kynnersley, M.C., an engineer who held a temporary commission in the Corps during the Great War.

[1] Portuguese *vallado*, a fence.

[2] *Western India*, by Mrs. Postans, as quoted in *The Rise of Bombay*, by S. M. Edwardes, p. 250.

[3] A " Back Bay Reclamation Company " existed in 1865, and proposed to reclaim the whole of the Back Bay, but it soon went into liquidation.

And now to Calcutta in the olden days. A dry dock was made on the Hugli by Mr. Robert Hedges, who became Governor in 1713, but it was not a success. "How it came about," wrote the Directors of the East India Company some years later,[1] "that Mr. Hedges was so overseen (?) in making the Dock without considering the great Charge it would stand in, the small Income it would produce or the constant Repairs it would require, We cant but wonder at." In 1726 they complained that the dock had lain empty for the last year as none but large ships used it; they admitted that Hedges' design was good but added that he should have laid a proper foundation and provided flood-gates. This dock must have been a very rudimentary work, for Admiral Pocock demanded a better one in 1758, and Robert Clive supported him, with the result that Captain John Brohier,[2] who was then engaged in building a new Fort William, was ordered to make a dock. He did so, and the dock was used until 1808. A certain Captain Barton[3] asked leave in 1759 to dig a channel from the Hugli to the big tank behind Old Fort William and to convert the tank into a dock for ships, and Captains John Brohier and Bartholomew Plaisted (a sailor) reported that there would be no objection to this scheme.[4] In these and other projects the military engineers of old Calcutta gained some useful experience.

For many years the construction of wet docks was proposed in Calcutta, and in 1780, at Kidderpore below New Fort William, Colonel Henry Watson, of the Bengal Engineers, began to establish both wet and dry docks and a marine yard, known as "Watson's Works," for repairing and equipping not only merchantmen but ships of war. He launched the *Nonsuch* (36 guns) in 1781, and the *Surprise*, with a similar armament, in 1788.[5] For eight years he devoted himself to this national undertaking, by which time he had sunk £100,000 in his enterprise. He was then obliged to abandon it, his resources being exhausted. "Watson's Works" afterwards passed to the Anglo-Indian sons of Colonel Alexander Kyd, late B.E., an enterprising Chief Engineer in Bengal who had been Surveyor-General in 1792 with the army before Seringapatam.[6] In 1818 the Kyds launched the *Hastings*, a 74-gun ship, and between 1781 and 1821, 237 ships were built in the Calcutta yards. It is interesting to note that on July 12th, 1823, the *Diana*, the first steamship built in India, was launched at Calcutta and had a splendid trial trip, being reported in the local newspaper to have shown a "velocity perfectly astonishing."

[1] General Letter, Court to Bengal, dated February 3rd, 1720. Letter Book, No. 17.

[2] Captain Brohier is mentioned many times in Vol. I, Chapters IV and VII.

[3] Not an Engineer.

[4] *Bengal Public Consultations*, June 7th and 14th, 1759. Range I, Vol. XXXI. Plaisted had become Surveyor of Works (see Vol. I, Chapter IV, p. 47). The conversion of the tank into a dock was never carried out.

[5] *Calcutta, Old and New*, by H. E. A. Cotton, p. 274.

[6] See the map entitled "*Seringapatam*, 1792," facing page 168, Vol. I, Chapter X.

Following in Watson's footsteps, a few military engineers continued to share in the maritime schemes on the Hugli. Captain J. A. Schalch, of the Bengal Infantry, came forward in 1884 with a plan for making wet docks in Tolly's Nullah, but the First Burma War ended his hopes. Again, in 1846, Lieut.-Colonel (afterwards Major-General) W. N. Forbes, B.E., the noted architect,[1] proposed to construct wet docks at Kidderpore at a cost of half a million sterling, and plans and estimates were prepared, but funds were not forthcoming and the scheme collapsed like many others. The Calcutta Port Trust took over the question of dock accommodation in 1869, and in 1884 Government agreed to the expenditure of £2,000,000 on the Kidderpore Dockyard. The work was soon taken in hand by civil engineers, the only connection of Royal Engineers with the undertaking being that Colonel (afterwards Lieut.-General) H. A. Brownlow and Lieut.-Colonel J. M. Heywood were invited to give some criticism and advice. So ended the work of the Corps in the Bengal dockyards, though several officers, some of whom were in command of Submarine Mining Sections, have assisted the Port authorities since those days in clearing the Hugli of wrecks, the pioneer in this line being Major W. R. Fitzgerald, B.E., who in 1840, with 2nd-Lieutenant Richard Baird Smith of the same Corps,[2] demolished with gunpowder the wreck of the *Equitable*.

No mention has yet been made of harbour and dock engineering in Rangoon or Karachi. As regards Rangoon, military engineers have done very little, their energies in Burma having been devoted more to lighthouses than docks. Rangoon is too modern a port to have needed their services. But they had a considerable share in the improvement of the port of Karachi and consequently their connection with that undertaking should be recorded.

Although Karachi can never rival Bombay, it is a first-class port serving the Province of Sind and much of the Punjab. The western half of its large harbour is formed by a long strip of sand ending in a rocky promontory at Manora Point, and the eastern half by the sandy island of Kiamari ; but in pre-Mutiny days the entrance between these places was obstructed by a bar of sand nearly 3,000 feet wide with a depth over it of only nine to twelve feet at low water spring tides. It was mainly to remove this bar, and to preserve a deep channel for shipping, that the works at Karachi were undertaken.[3]

The question of improving Karachi Harbour was raised in 1844 by Major-General Sir Charles Napier after he had annexed Sind ; and by 1853, when Mr. Bartle Frere was Commissioner, a timber pier had been erected at Kiamari Island, and the Napier Mole or causeway, two miles in length, had been built to connect that island with the

[1] See Chapter VI, p. 93.
[2] Afterwards Lieut.-Colonel Baird Smith, Chief Engineer at the siege of Delhi in the Indian Mutiny.
[3] *Ways and Works in India*, by G. W. MacGeorge, p. 510.

town of Karachi.[1] For the next three years the deepening of the harbour was much discussed by the Government engineers, headed by Major (afterwards General) H. Blois Turner, Bo.E., Superintending Engineer, P.W.D., in Sind, on whose advice accurate surveys were made. These were sent to Mr. James Walker, an eminent harbour engineer in England, who declared that it would be possible to remove the bar, adding that an expert should be despatched to India to make a further report. The selected expert was Mr. William Parkes, whose report in 1858 enabled Walker to recommend the construction of several large works, at an estimated cost of about £300,000, including a breakwater, 500 yards long, from Manora Point. But Government jibbed at the expense and sanctioned only a groyne from Kiamari Island to the entrance opposite Manora Point and some tide-diversion works east of the island. A sum of £137,000 was allotted for this modified scheme in February, 1859, when the general superintendence of the work was given to Blois Turner,[2] who had had frequent conferences with Walker in England. Under Turner was Mr. W. H. Price[3] in immediate charge of the work, and on Price's staff was an energetic young subaltern, Lieutenant G. L. C. Merewether, Bo.E., whose subsequent labours in Bombay have already been mentioned. Price began his operations early in 1860 and continued them for several years; but during 1864 and 1865, when Price was ill, Merewether was in supreme charge of the work.

The Karachi Harbour Improvement Scheme had a chequered career. In 1861 Blois Turner was succeeded as Chief Engineer by an officer of very decided opinions, Colonel (afterwards Lieut.-General) C. W. Tremenheere, late Bo.E., who objected to Walker's plans and persistently urged their abandonment. The building of the Kiamari groyne was begun in November, and, by April, 1863, a length of 1½ miles had been completed; but Walker's estimates were being greatly exceeded by Price, the Resident Engineer, and a proposal by the latter to extend the groyne still farther, though supported by Colonel (afterwards Major-General) Charles Scott, Bo.E., then Chief Engineer in Bombay, was rejected by Tremenheere. At length Walker sent Parkes again from England in 1864 to reason with Tremenheere, but no agreement having resulted even in 1865, the Government invited the independent opinion of a firm in Edinburgh and issued orders in April, 1866, to stop all work.

The Secretary of State for India is a valuable arbiter in a deadlock such as that at Karachi, even though his chief functions, as described by an Indian schoolboy, may be "to appoint and disappoint the senior officials." In this case he appointed the Governor of Bombay

[1] Article entitled "Memoir of Kurrachee Harbour," by W. H. Price, appearing in *Professional Papers on Indian Engineering*, 2nd Series, Vol. III, 1874, Paper CXVII, p. 191.

[2] Blois Turner had become a Colonel, and was then Chief Engineer P.W.D., in Sind.

[3] Price was an Executive Engineer in the Sind Irrigation Department.

to adjudicate between Tremenheere and Parkes. On most points the Governor found for Parkes, so active operations were resumed early in 1869, and by 1873 the Manora Breakwater had been built at a cost of £70,000. In the following year the whole scheme was practically finished after an expenditure of some £450,000 ;[1] but the connection of military engineers with the work had already been severed, for Major G. L. C. Merewether had left Karachi for Bombay in October, 1870. He had worked for ten years on the new harbour, and it may justly be said that the modern port, so greatly improved and enlarged since his day, owes much of its prosperity to his energy and resource.

Many Royal Engineers on the Indian establishment have been attracted to what may be called the nautical side of their profession, and have excelled in the building of lighthouses. Although the birthplace of lighthouses in India was Bombay, no record exists that any guide to shipping was provided when the island belonged to the Portuguese. Indeed, for a century after it passed into British hands, the only landmarks for vessels entering the harbour were a few tombs and a house which were kept regularly whitewashed.[2] About the year 1766, however, two signal-houses were erected, one on Old Woman's Island[3] and the other at Malabar Point, the former being soon replaced by the first proper lighthouse in India, whose construction was begun in 1768 and finished three years later. It is reasonable to suppose that this building was erected by one of the Company's engineers under the orders of Lieut.-Colonel Thomas Keating, the " Principal Engineer " at that time, or of Captain Lawrence Nilson, who sometimes acted for him,[4] and its cost (about £450) was met by a duty imposed on all ships anchoring in the harbour. " The reflectors being apt to become very dim from the smoke of the lamps," wrote the Directors, " we direct that transparent cocoa-nut oil only be burnt as the *jingely* and other oils in general use are very productive of lamp-black."[5] Yet this lighthouse threw a beam more than seven leagues seaward in clear weather, and being an imposing structure 150 feet high, shared with the Mint, the Dockyard and the Town Hall the honour of being one of the recognized sights of Bombay. In after years it was repaired by several Bombay Engineers, among them being Major Thomas Dickenson in 1828 and Captain F. Wemyss when Dockyard Engineer in 1853. It stands to this day as a monument of sound construction, but it ceased to be used as a lighthouse when the Prongs Light was installed in 1874.

The " Colaba " Lighthouse, as it was called, was very soon found

[1] About 50% more than the original estimate by Mr. James Walker.
[2] *The Rise of Bombay*, by S. M. Edwardes, p. 191.
[3] Now part of Colaba.
[4] See Vol. I, Chapter VI, p. 97.
[5] *Gazetteer of Bombay City and Island*, Vol. I, p. 58.

to be insufficient to guide vessels safely into Bombay Harbour. As early as 1841 there was a demand for another lighthouse to safeguard shipping from the dangers of the Prongs Reef, the deadly barrier which runs southward from Colaba Point. In 1855 the Commander-in-Chief of the Indian Navy[1] requested that a small tower with a fixed light should be built on the Dolphin Rock near the Apollo Bunder in place of a wooden beacon, and this application being supported by the Chief Engineer, Major-General Charles Waddington, C.B., late Bo.E., Captain Wemyss raised the tower which still lights the harbour.[2] Gradually the lighting of the port was extended. Captain (afterwards Lieut.-General) C. W. Tremenheere, Bo.E., had placed a beacon in 1852 on Khanderi (Kenery) Island, some miles south of Bombay, but had been ordered to remove it as its light was mistaken for that of the Colaba Lighthouse. In 1866, however, it was found necessary to construct a proper lighthouse at Khanderi, and this work was taken in hand and completed by a civil engineer.

Of the many lighthouses and beacons now marking the approach to Bombay, the most famous is the Prongs Lighthouse, well known to travellers in the East. Several military engineers were concerned in its design and construction. In 1860 an officer of the Indian Navy proposed that a lighthouse should be built, and a long controversy ensued as to the best site, some favouring one in deep water and others a situation as far out as possible on the ridge of rock called the "South-west Prongs," which was exposed at low-water spring tides. Eventually a site on this ridge was selected, and in 1864–65 plans and estimates were prepared by Lieut.-Colonel Jenkin Jones, R.(Bo.)E. These, however, were rejected, and further discussions followed in which Major-General C. W. Tremenheere, Colonel Alfred De Lisle and Lieut.-Colonel Jenkin Jones, took part, with the result that Captain W. M. Ducat, R.(Bo.)E., prepared revised designs for a stone tower which met with approval.[3] Work began in the autumn of 1868 under the direction of Tremenheere, who was then Chief Engineer of the Presidency Division, and it remained under his control until August, 1870, when Mr. Thomas Ormiston, Chief Engineer of the Harbour and Pilotage Board, took charge and completed the operations in November, 1874. The resident engineer during the first 2½ years was Lieutenant W. Osborn, R.E., and Captain Ducat was also engaged on the scheme for six months. Whilst the work was under military control the foundation was set, the base completed, and four courses of the tower laid. The Prongs Lighthouse, when finished, was one of the largest in the world and had cost about £60,000. Although it was built mostly by Ormiston,

[1] The Indian Navy was formed in 1832 and abolished in 1862.

[2] In 1929 the Bombay Port Trust provided this lighthouse with an automatic acetylene light.

[3] The Prongs Lighthouse, as erected, was 127½ feet high, 42 feet in diameter at the base and 16 feet at the top. The stone employed was hard grey trap.

its foundation had been prepared by Tremenheere and his Royal Engineers.

Madras was slow to follow the example of Bombay, and no proposal was made to light its roadstead until 1794, when someone rashly suggested that, instead of rebuilding the fallen steeple of St. Mary's Church in Fort St. George, a lighthouse should be erected on the church tower.[1] Instantly the chaplains lodged a protest against the church being put to "any profane or common use whatsoever,"[2] so the scheme was abandoned. Instead, a fixed light[3] was installed in 1796 on the Exchange building, and this had to suffice for many years. The man who eventually secured Madras her first proper light was Captain J. T. Smith, M.E. As a subaltern he went on leave to England in February, 1834, and spent much of his leisure in examining and selecting lighthouse apparatus. At the end of 1837 he arrived in Madras with a novel apparatus, costing £1,500, in which the reciprocating principle was adopted instead of the ordinary rotary motion. A site having been selected on the beach, Smith and his contractors began the excavations of foundations for a lighthouse on July 17th, 1838, and Lord Elphinstone laid the first stone on September 19th. Lieutenant (afterwards Major-General) S. E. O. Ludlow, M.E., joined the staff in 1841, and on New Year's Day, 1844, the work was completed and the lamp threw a beam 15 miles out to sea.[4]

Smith's lighthouse no longer illuminates the rolling surf. "Few would imagine," writes Colonel Newall,[5] "that the graceful fluted column to the south-east of the High Court had once been a lighthouse. Beautifully fitted blocks of Pallavaram gneiss lend the pillar an appearance of solidity and strength and allow no hint to transpire of its brick framework. The design is that of a Greek Doric column, 125 feet in height." Many years before these lines were penned by Newall, the light had been transferred to the dome of the High Court building from which it now shines. It seems that Smith was often attacked for the apparent slowness of his work, but he was a master in the art of turning away wrath and always proved that his tormentors were in the wrong. There is to-day, in the local office of the Mercantile Marine Department, a brass plate bearing an inscription to the effect that the Madras light, as designed by Captain J. T. Smith, was the first to be constructed on the reciprocating principle.

After his return from furlough in 1840, Smith was busily engaged for a time on a lantern for a lighthouse at Mangalore on the west coast, and in designing a light for Masulipatam Harbour on the east

[1] *The Church in Madras*, by Rev. F. Penny, p. 394.

[2] *Madras Public Consultations*, February 27th, 1795.

[3] A framed iron structure, with a lantern, reflectors, and 12 lamps burning coconut oil.

[4] The light was of a flashing description, the ratio of flashes to eclipses being as two is to three.

[5] *An Illustrated Guide to Madras* (1919), by Lieut.-Colonel H. A. Newall, F.R.G.S., Indian Army, p. 64.

coast. He was responsible also for the first light at Cochin. His reputation as an expert in illumination became so firmly established that as late as 1856 he was asked by the Madras Government to advise them on any improvements in lanterns which he had noticed recently in England. He was then a Lieut.-Colonel, on the eve of retirement, and holding the post of Mint Master in Calcutta, so that it is evident that he followed his hobby to the end of his service. Few Royal Engineers have specialized to such an extent in optics.[1]

Shortly before the foundations of the Madras lighthouse were laid, 2nd-Lieutenant (afterwards General) Henry Righy, M.E., working under Captain H. De Bude of the same Corps, finished the construction of a fine lighthouse at False Point, near the mouth of the Mahanadi in Orissa. It was built of laterite blocks resting on a wooden grillage founded on sand, and exhibited its light for the first time in March, 1838. This light, though still used by the coasting trade, is no longer an essential guide to the Hugli entrance, as vessels can now steer straight for the outer lightships at the Sandheads.[2]

Further eastwards, on the coast of Arakan, the building of the Great Savage Rock Lighthouse at the entrance to Akyab Harbour was the cause of much correspondence. Early in 1838 Lieutenant R. Martin, B.E., sent rough estimates to Captain Bogle, the Commissioner of Arakan, for a pile jetty and a lighthouse on the rock, following these with detailed estimates which Bogle picked to bits when forwarding to the Military Board. But there was at least one humorist in that august body, for against a remark by Bogle that a jetty could be built for a much smaller sum than that proposed by Martin, is the pencilled comment "Let Captain Bogle try." The Board supported Martin, and although a jetty was not sanctioned, he was allowed soon afterwards to begin the construction of the lighthouse. In 1840, having removed 35 feet from the top of the rock by blasting, he submitted an estimate for Rs. 12,238-5-5, the extreme accuracy of which must have been welcomed by the Accounts Department. But Bogle was not satisfied; he wanted the remainder of the rock removed—some 32,000 cubic feet. Naturally Martin objected. "The only object obtained," wrote he, "will be that the whole of the building will be seen from the station, some three miles away, instead of one half." Yet, on this purely æsthetic ground,

[1] Captain J. T. Smith, M.E., wrote many reports and articles on lighthouses and their apparatus. Among them may be mentioned his articles entitled "The Madras Lighthouse," "On a New System of Fixed Lights," and "Description of a new Hydro-Pneumatic Lamp," appearing in *Professional Papers of the Madras Engineers*, Vol. I, 1859.

[2] At the Hugli entrance are the Kaukhali (Cowcolly) light, erected on the right bank in 1810, and the Saugor light on an island near the left bank. In 1821 the Saugor light was a tripod beacon, This was replaced by a lighthouse (in 1852), which was dismantled and rebuilt on a new site in 1911. The Hugli now has a number of lightships and gas-buoys, but its lighting has been done by civil engineers alone.

Government actually sanctioned the removal of the extra rock ![1] It is sad to relate that Martin died at Akyab on July 1st, 1842. The fact is recorded on a stone tablet in the lighthouse where a brass plate shows also that the work was completed in 1844 by Lieutenant H. Siddons, B.E.

The story of the Great Savage Rock Lighthouse suggests a tale of the Oyster Island Lighthouse a few miles distant. Lighthouse keepers all the world over are usually excellent and reliable men, but an exception sometimes proves the rule. One day a passing ship picked up a signal from the Oyster light which ran, " Instruct Port Officer, Akyab, lighthouse falling down. Arrange relief." Off dashed the Port Officer through the vilest weather to the scene of the supposed disaster. As he approached the lonely tower he scanned it carefully but could see nothing amiss, nor could he find anything unusual when he had entered it except that the half-yearly issue of methylated spirit for cleaning the prisms of the lamp had been completely exhausted in less than a month. A further search revealed a recumbent but jovial keeper, firmly convinced that the solid walls around him were still whirling and crashing to ruin. Allowances should be made for solitary men who exceed their allowances.

On Table Island, north of the Andaman group, is the Cocos Island Lighthouse, a meteorological station where the keepers are required to take readings of thermometers and other instruments. A new keeper was sent to the island, and some months later an inspecting officer arrived and called for the meteorological records book. On looking through it he was amazed to see that the readings of the wet and dry bulb thermometers were exactly the same for every day of the preceding six months. " Well, sir," explained the keeper, " when Jones 'anded over to me, 'e said, ' This 'ere instrument *always* reads the same, so don't you worry about it. Just enter up the same figure every day.' So I done wot 'e says." The explanation is simple. The bulb had burst.

The first reference to the celebrated Alexander Fraser, the leading military builder of lighthouses, occurs in December, 1853, when Lord Dalhousie landed on the Alguada Reef while on his way to Burma.[2] This long and dangerous ridge lies well out to sea off Cape Negrais, exactly where a ship voyaging from Calcutta to Rangoon turns eastwards. It is almost submerged at high tide and is a trap of the deadliest description. Although the Viceroy ordered that an engineer should be sent at once to report on the possibility of constructing a lighthouse, the project seems to have languished for a time until, in October, 1856, Lieutenant Alexander Fraser, B.E.,

[1] The cheapness of labour may supply an explanation. Stone cutters received only five annas a day, and coolies three or four annas.

[2] Volume entitled " Selection of Papers regarding the Construction of a Lighthouse on the Alguada Reef," appearing as No. XXV of *Selections from the Records of the Government of India, P.W.D.*, 1858.

ALGUADA REEF LIGHTHOUSE.

Originally designed and built by Capt. A. Fraser, Bengal Engineers.

was deputed to survey the reef and afterwards to proceed to Europe to gather information about modern lighthouses and lights. Landing on the Alguada for the first time on December 28th, Fraser surveyed it thoroughly, afterwards visited several lighthouses, wrote his report, and embarked for England in February, 1857. Then came the Indian Mutiny, during which, unable to reach India, he studied the details of the Eddystone, Bell Rock, Skerryvore and other lighthouses at home, so that, when he landed in Calcutta in April, 1858, he was becoming an expert in his particular line. His estimates for the Alguada light having been sanctioned, he began the foundation work late in 1859 and laid the first stone on February 14th, 1860. Fraser was then a Captain and had, as his assistants, Lieutenants J. M. McNeile and F. P. Spragge[1] of his own Corps. The lighthouse was built of granite imported from Singapore and was modelled on the famous Skerryvore in Scotland.[2] A graceful tower, whose lantern is 142 feet above the sea at high tide, it is a prominent landmark by day, and its light is visible at night from a distance of 23 miles. Its construction occupied more than five years, for it was not until April 23rd, 1865, that the lantern was first lighted. Considering the difficulty and duration of the work, its cost, which amounted to about £100,000, was not excessive ; and not a life was lost during the operations.

In 1863, while still engaged at the Alguada Reef, though in control also of the construction of lighthouses on Double Island[3] and Table Island, Fraser submitted a most comprehensive report on the lighting of the Burmese coast. His trusty assistant, Lieutenant J. McNeile, R.(B.)E., finished the building of the Double Island Lighthouse at the end of 1865.[4] The Table Island Lighthouse was completed in 1867 and is still in use. Before the end of 1870, Fraser and his assistants had also designed and built screw-pile lighthouses on Oyster Reef between Akyab and Alguada, at the Krishna Shoal and China Bakir between Alguada and the Rangoon River, and at Eastern Grove at the mouth of that river, and they had begun the remodelling of the Great Savage Rock Lighthouse. The Oyster Reef and Krishna Shoal towers no longer exist : they have been replaced by a tower on Oyster Island and a lightship on the Krishna Shoal. Lightships are now employed at several eastern ports, but Fraser

[1] Lieutenant F. P. Spragge, R.(B.)E., was employed on the work for about a year ; but Lieutenant J. M. McNeile remained until the work was finished, with periods of duty elsewhere.

[2] An excellent account of the building of the Alguada Lighthouse is given in an article entitled " The Alguada Lighthouse," appearing as No. LXXXII in *Professional Papers on Indian Engineering*, Vol. II, 1865, pp. 304–307.

[3] In the Gulf of Martaban, east of Rangoon.

[4] The Double Island Lighthouse was abandoned in 1926 owing to a severe landslip close to it. Its construction is described in an article entitled " The Double Island Lighthouse," compiled from reports by Lieutenant McNeile, which appears in *Professional Papers on Indian Engineering*, Vol. III, 1866, Paper CIV, pp. 129–132. The work was begun in October, 1862, but a light was not shown until December, 1865, owing to delay in fixing the lantern.

considered them much inferior to lighthouses owing to the fact that four lightships were lost with all hands, through storm or collision, during a period of five years when he was in control.[1]

Fraser's activities extended far beyond the shores of Burma. In 1867, as a Captain, he sent a report to the Board of Trade on the lighting of the Red Sea, where very little had been done to safeguard shipping. Previous to this he had submitted designs for lighthouses on the Great Basses, off the eastern coast of Ceylon, which were approved by the Trinity Corporation (now Trinity House), although there is no record that they were used in building the existing lights. His report on the Red Sea lights unfortunately fell on stony ground. There were political difficulties, and no one would venture to state the ownership of the Red Sea islands.[2] In 1881, as a Major-General and Secretary to the Government of India, P.W.D., Fraser drew attention once more to the lighting of the Red Sea where he had recently seen two ships stranded on a point which was the site proposed for one of his lighthouses. In time his representations had their effect. The Red Sea is now splendidly lighted, and every important light is situated in the position recommended by Fraser. Many a ship would be at the bottom of the sea were it not for the persistence and energy which he displayed more than half a century ago.

There are a number of small lights along the coasts of India and Burma which were erected by military engineers in the course of their civil duties. The Saugor Island Lighthouse in the Hugli, for instance, was rebuilt by Lieut.-Colonel (afterwards General) Henry Goodwyn, B.E., about the year 1852. Captain W. W. Goodfellow, R.(Bo.)E., completed the building of the Karwar Lighthouse, south of Goa on the west coast, in 1864; and Major W. H. Haydon, R.E., assisted by Lieutenants W. W. Baker and A. C. Joly de Lotbinière, R.E., was engaged in erecting a lighthouse on Manora Point at Karachi in 1889. Farther afield Captain (afterwards General) C. J. Merriman, R.(Bo.)E., built a lighthouse on Ras Marshag at Aden in 1867 from a design prepared three years earlier by 2nd Captain H. Pym, R.(Bo.)E.; and Major (afterwards Major-General) E. D'O. Twemlow, R.(Bo.)E., constructed Perim Island Lighthouse in 1885 with the help of Lieutenant P. E. Dixon, R.E. In the Madras Presidency, between 1900 and 1903, no less than eleven excellent lighthouses were erected, mostly by Conductor (later Hony. Captain) C. Smith, R.E., who eventually acted for a time in charge of the Lighthouse Division.

[1] Article entitled "Lighthouses on the Coast of British Burma," by Colonel A. Fraser, C.B., R.(B.)E., appearing in *Papers on Indian Engineering*, Vol. I, Part 1, 1892, No. XIX, pp. 174–183. This valuable article gives details of all his Burma lighthouses.

[2] The subject of the report, however, was not forgotten, for in 1870 Lieut.-Colonel (afterwards Lieut.-General Sir) Andrew Clarke, C.B., C.M.G., C.I.E., R.E., read a paper, before the Royal Geographical Society, on the Suez Canal and the general lighting of the Red Sea. This paper was prepared in collaboration with Captain Richards, R.N.

Almost to this day the Corps has maintained some connection with lighthouse work in India, for in 1927, when Mr. D. Alan Stevenson, an expert from home, was engaged by Government to report on the formation of a Central Service of lights in India and Burma, Captain R. B. Emerson, R.E., was appointed from the Railway Department to be his assistant and to accompany him on tours of the lighthouses around India, Burma and the Persian Gulf. This he did between February and July, 1927, and when the Central Service was formed in 1929, he became the first Inspector of Lighthouses in British India under Mr. John Oswald as Chief Inspector, and held the appointment for two years.[1] Before the Central Service came into existence, each Maritime Province was responsible for its own lights; but several improvements have been effected under the new régime, and two modern lighthouses have been erected on the west coast of India, one of which (the Vengurla Rocks)[2] is the most powerful light in the country, giving a beam of 1,250,000 candle-power. The coasts of India are now well and efficiently lit.

Most Royal Engineers are fond of the sea. A crew of young officers has sailed a yacht across the Atlantic: other crews have raced in stormy weather round the Fastnet. Some officers have served for years as Submarine Miners. During the Great War the author covered hundreds of miles on the Tigris in command of a flotilla of launches towing rafts with which he bridged the river. There seems to be a nautical strain in Sapper blood; and it is fortunate, perhaps, that this has shown itself in India, for it has helped, through the provision of harbours, docks and lighthouses during the past century, to create and maintain that supremacy in sea-borne trade which is the mainstay of our Eastern Empire.

[1] From May, 1929, to February, 1931, when he rejoined the Railways on being succeeded by an Indian officer. The author is greatly indebted to Captain R. B. Emerson, R.E., for much of the information on lighthouses which appears in this chapter.

[2] The original Vengurla Lighthouse was built about 1870 on a site selected by Captain C. J. Merriman, R.(Bo.)E., in 1864. This site being too exposed, another lighthouse was built in 1890 on an island nearer the mainland. This tower was demolished and replaced by the existing lighthouse in 1932.

CHAPTER XI.

EARLY HISTORY OF THE SURVEY OF INDIA.

"We engineers pride ourselves upon the benefits conferred upon this country by our roads and railways and canals; but I feel that we ought, in fairness, to acknowledge that the Survey of India has been the foundation stone upon which we have always built. Whatever part of the country I have had to visit, and whatever project I have had to consider, the maps of the Survey have been my basis of knowledge."—*Speech by Sir John Benton, Inspector-General of Irrigation in India in* 1912.

IN the year 1764, a youngster named James Rennell, who had been a midshipman in the Royal Navy, sailed up the Hugli in command of a small coasting vessel. He had lost most of his possessions by shipwreck and was almost friendless; yet, soon after his arrival, he was appointed Surveyor-General of Bengal[1] and received a commission in the Bengal Engineers. This miracle was the work of Clive, who was then watching the growth of Fort William, his great stronghold in Calcutta, and it marked the true beginning of the Survey of India. To place a young man of only twenty-one years of age in a position of such responsibility was a bold step; but Clive was given to experiments of this nature and was a fine judge of men. In this case, as in many others, his action was justified by the results.

James Rennell, now known as the "Father of Indian Geography," laboured in Bengal and elsewhere for a period of 13 years, during which he surveyed an area of about 300,000 square miles, stretching from the eastern boundaries of Lower Bengal to Agra, and from the Himalayas to the borders of Bundelkhand and Chota Nagpur. Unhappily he was obliged to leave India in 1777 on account of ill-health, but he had already blazed a trail which others followed eagerly. Guided to some extent by a map of India prepared in 1752 by a Frenchman named D'Anville, and by a number of route surveys executed by military officers of the East India Company, Rennell embodied the results of his labours in an atlas of Bengal, which was published in 1781, and, seven years later, produced his famous map of India. This map, and a memoir which followed it, mark the starting-point in the history of map-making by the Government of India. "Among his eager fortune-seeking countrymen in Bengal," writes Thackeray,[2] "Major James Rennell stands forth as

[1] Rennell was actually "Surveyor" from 1764 to 1766, and "Surveyor-General" from 1767 till the end of 1776.

[2] Memoir of Major James Rennell, F.R.S., appearing in *The Royal (Bengal) Engineers*, by Colonel Sir E. T. Thackeray, V.C., K.C.B., pp. 16, 17. Memoirs appear also in *Major James Rennell* by C. R. Markham (1895), in *The History of the Corps of Royal Engineers*, by Major-General W. Porter, Vol. II, pp. 401–404, and in *The R.E. Journal*, Vol. 12, 1882, pp. 9–13 (by Colonel H. Yule). Rennell died in 1830.

a unique figure—a calm, disinterested man of science. On his labours our knowledge of India rests. All the honours of science, Rennell reaped. For other distinction he cared nothing." Yet he was destined to have a posthumous distinction enjoyed by few military engineers, for his bust occupies an honoured place in Westminster Abbey.

Since its birth in the eighteenth century, the Survey of India has reached a pinnacle of world-wide fame. The work which has been achieved can only be pictured in its correct proportions by comparing it with the surveys of Europe and America. The Indian survey covers an area larger than the combined surveys of Great Britain, Ireland, France, Germany, Austria, Switzerland and Italy.[1] The arc of longitude embraced by the Indian triangulation would reach, in Europe, from London to the Caspian Sea, and in America from the coast of Florida on the Atlantic to that of California on the Pacific. The arc of the triangulation executed between Cape Comorin and the Karakorum mountains would stretch, in Europe, from Greece to Lapland, and, in America, from the Gulf of Mexico to the Hudson Bay. In the Himalayas, in the Karakorum, and recently in the Hindu Kush, our surveyors have fixed several mountains which are more than 10,000 feet higher than Mont Blanc, and have actually observed from many summits whose altitude is much greater than that of the loftiest peak in Europe. In recent times, the Survey of India has often benefited from the experiences of Europe and America; but it can also justly claim to have given a lead, on occasions, to other countries. It did so to Europe in its measurement of the arc of meridian and in its re-determination of the figure of the earth; and it led Europe in its observations of the pendulum, its measurement of the oceanic tides, and its geodetic researches. The records of the great surveys of Great Britain, France, Germany and the Alps, show that these surveys have been in close and constant touch with the scientists and mathematicians of Europe. Honoured names, such as those of Maupertuis, La Place, Bessel and Airy, figure in their annals. But the surveys of India have been designed and carried out by officers of the Army, educated at Addiscombe and Woolwich, and, during the first half-century, momentous scientific decisions had often to be taken without the possibility of consultation with Europe. The execution of a geographical survey was never even considered by the Asiatic rulers of India. It was left to Great Britain to show the way, and, for the most part, her surveyors have been military engineers.

Rennell's system of field work in Bengal consisted chiefly of a survey of routes, checked and combined by astronomical determinations of latitude and longitude, and a similar system was adopted

[1] Notes given to the author by Colonel Sir Sidney G. Burrard, K.C.S.I., F.R.S., late R.E., in October, 1933. These notes have been used extensively during the course of these chapters on the Survey of India.

in other parts of India.[1] It was soon discovered, however, that the errors in the astronomical observations often exceeded those of the actual survey, and consequently the observations formed an unsatisfactory basis on which to found topographical work. A properly co-ordinated scheme of triangulation, embracing the whole of India, was needed to fix important points, and it fell to Rennell's successors to evolve and elaborate that scheme. But meanwhile, in the absence of more precise and reliable information, Rennell made full use of a number of coastal surveys, and of the route surveys of Major-General Goddard from the Jumna to Poona, of Captain Charles Reynolds[2] through Malwa, of Colonel Fullarton in Coimbatore, of Lieut.-Colonel John Call, M.E., in Tinnevelly, of various British officers during the earlier Mysore Wars, and of the French general, Bussy, in the Deccan.[3]

Many years before Rennell landed in India, Revenue, or "Cadastral," Surveys had been executed in certain areas for the purpose of taxation. In Madras, for instance, an official known as the "Rentall Generall" was ordered in 1697 to measure the ground belonging to every house, and in 1726 the "Rentall Generall and Scavenger" received similar instructions.[4] By means of these and other measurements, a map of that locality was produced in 1733.[5] In Bombay, Colonel Herman Bake, a German, was appointed Engineer and Surveyor-General in 1672,[6] and almost completed a map of the town. A century later, a Revenue Survey of the whole island was begun which afterwards proved of some value to Lieutenant John Hawkins and Captains Thomas Dickenson and W. A. Tate, all of the Bombay Engineers, the last of whom carried the scheme to completion in 1827. Between 1742 and the end of the eighteenth century, many surveys were made of Calcutta, and the plans so produced are interesting and instructive.[7] Although Revenue Surveys have not usually come within the province of military engineers in India, a number of such officers assisted in this work before, and shortly after,

[1] Address delivered by General J. T. Walker, C.B., F.R.S., late R.(Bo.)E., to the Geographical Section of the British Association in 1885, appearing in *The Indian Engineer*, January 22nd, 1887, p. 161, *et seq.*, and forming the basis of the account of the Survey of India given by General Porter in the *History of the Corps of Royal Engineers*, Vol. II, pp. 248–254.

[2] Captain C. Reynolds, Bo.I., ended his service as a Lieut.-General and Surveyor-General of India (see Vol. I, Chapter XI, p. 192 and footnote).

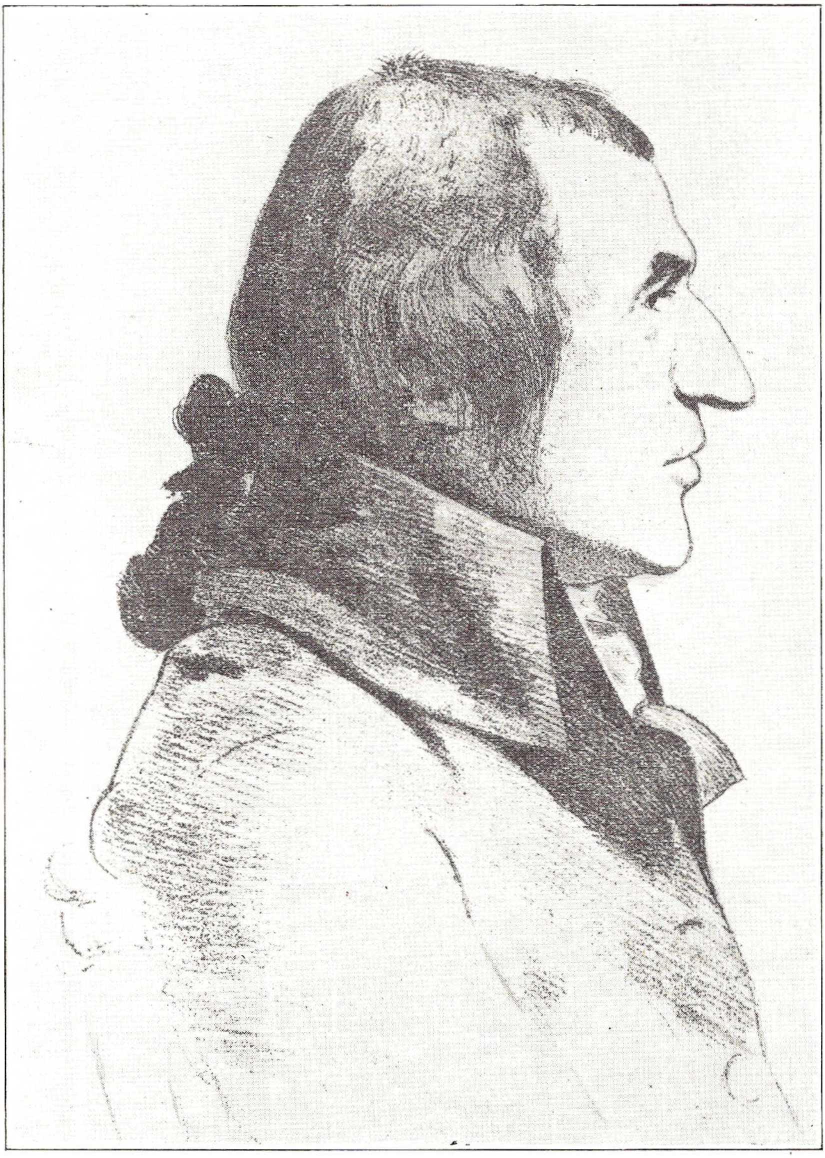
[3] *A Memoir on the Indian Surveys*, by Clements R. Markham, 2nd Edition, 1878, p. 401. This book is a most comprehensive and reliable guide to the early history of the Survey of India.

[4] *Madras Public Consultations*, Vol. XXV, August 26th, 1697, and Vol. LVI, December 19th, 1726.

[5] *Vestiges of Old Madras*, by Colonel H. D. Love, Vol. II, p. 253.

[6] See Vol. I, Chapter II, pp. 20, 23, 27.

[7] Among these plans may be mentioned those by Aloffe and Forresti (1742), Lieut. W. Wells (1753), J. Van Ryne (1754), A. Upjohn (1756 and 1792), Captain C. Martin (1764) and Lieut.-Colonel Mark Wood, B.E. (1785 and 1792). Early in the nineteenth century plans appeared by Captain T. Prinsep, B.E., and Major J. A. Schalch and others.



MAJOR JAMES RENNELL, F.R.S., BENGAL ENGINEERS.

the Indian Mutiny. For example, between 1822 and 1842, many districts lying west of Jumna, in the Ganges *doab*, and in Rohilkhand, Orissa, Bihar and Nagpur, were surveyed by the Company's engineers. Between 1836 and 1866, Lieutenant (afterwards Major Sir George) Wingate, Bo.E.,[1] elaborated the original design of the Bombay Revenue Survey, his indefatigable labours resulting in an admirable system of administration which promoted the revival of agriculture throughout the Presidency. In 1865, Captain D. J. Nasmyth, R.(Bo.)E., of the Survey of India, began a triangulation of the Island of Bombay in connection with a new Revenue Survey, handing over charge, in the following year, to Captain (afterwards Major-General) C. T. Haig, R.(Bo.)E., the detailed work of surveying each property being carried out meanwhile by Major G. A. Laughton, Bo.I., who ultimately completed the scheme in 1872. It is unnecessary to remark further on Revenue Survey work. The military engineers of India have been concerned chiefly in the more important branches of trigonometrical and topographical surveying.

While Rennell explored Bengal and Bihar during the comparatively peaceful era which followed Clive's victory at Plassey, Southern India was torn with the Maratha and Mysore Wars. Surveying, of a primitive kind, was accomplished in many theatres of the military operations, but the results were not inspiring. In 1778, Captain Robert Kelly, of the Madras Infantry, suggested that a military survey should be made of a large part of the peninsula. "I propose," said he,[2] "a General Map of the Decan and Carnatick, chiefly laid down from actual Surveys, Corrected by Astronomical Observations and divided into Parallelograms each containing One Degree of Latitude and Longitude, Each of which will be illustrated by a particular Sketch on a large Scale." Although the Directors refused to sanction this scheme they must have considered it closely, because, within a few years, they invited Lieut-Colonel Patrick Ross, M.E., to formulate proposals on the subject. Ross wrote in 1783:[3] "A General Survey of the Countries immediately belonging to, and dependent upon, the Honble Company in this part of India has long been an object of attention. Some attempts have been made at different Periods, but these failed almost in the Origin. . . . I can almost venture to assert we are at this moment possessed of less materials towards furnishing a complete Chart of the Southern Part of India than we were at the period ten years back."

The Governor of Madras, a famous military engineer named Sir Archibald Campbell,[4] took the matter up in 1786, ordering that an astronomical survey should be made, and engaging Mr. Michael

[1] Uncle of General Sir Reginald Wingate, G.C.B., G.C.V.O., G.B.E., K.C.M.G., D.S.O., famous in Egypt and the Sudan.
[2] *Madras Public Consultations*, Vol. LXVIII, December, 1778.
[3] *Ibid.*, Vol. CXXXI, October 28th, 1783.
[4] See Vol. I, Chapter VIII, p. 133, footnote, and p. 134. ; and also Vol. II, Chapter XVII.

Topping, "a person of very considerable Mathematical and Geographical knowledge," to fix the latitude and longitude of the principal coastal stations and towns in the Carnatic. Topping began the southern survey in 1788, after securing the services of Mr. John Goldingham ("a young gentleman who had had a regular Mathematical Education") to take observations at a private observatory leased from a certain Mr. William Petrie.

It seems that Topping was not satisfied with Petrie's observatory and, without consulting the local engineers, submitted a design for a new building. This roused the wrath of Major George Maule, M.E., the Chief Engineer, who stated that, so far as he could see, Topping's plan was merely "a rectangular figure with the word 'Observatory' written within its area and a Meridian line drawn through it."[1] Topping replied, mildly enough, that the scale could be determined with the aid of compasses. To which the fire-eating Maule retorted: "I assert that neither the Compasses, nor all the instruments of a Vitruvius, a Palladio and Inigo Jones together, could select, from what is exhibited by Mr. Topping, a single Datum of any Decision." Nevertheless, Topping was allowed to build his observatory, and completed it in 1792, four years prior to his death. The Madras Observatory was destined to become of world-wide importance. From it sprang that vast gridiron of triangulation which gave the shape of India and facilitated the pendulum operations for the determination of the forces of gravity and the form of the earth.

While the Madras Observatory was under construction, a subaltern of the Madras Engineers, named Colin Mackenzie[2], was establishing a reputation as a surveyor with the British army engaged in fighting Tipu Sultan. Later, he became famous also in the field of antiquarian research. After the close of the Third Mysore War in 1792, Mackenzie made his first attempts to methodize and embody the geography of the Deccan, and after the Fourth Mysore War he surveyed the whole of the captured province. Having completed this project in 1809, he sailed with the expedition to Java in 1811 and remained on that island for four years, engaged in topographical and antiquarian work. So valuable were his services that after his return he was made Surveyor-General of India. Regarding his work in Mysore, the Directors wrote: "The actual survey, upon geometrical principles, of a region containing above 40,000 square miles, generally of an extremely difficult surface, full of hills and wildernesses, and never before explored by European science, in a climate very insalubrious, is itself no common performance; and the minute details of places given in the memoirs of the survey, with the

[1] *Madras Public Consultations*, Vol. CLXXI, August 5th, 1791.

[2] A portrait of Colonel Colin Mackenzie, C.B., F.R.S., appears opposite p. 164 in Vol. I of this work. His services are mentioned on pp. 163, 165, 166, 171, 232 and 233 of that volume. He became Surveyor-General of Madras in 1810 and of India in 1816. He died in 1821. Details of his archæological achievements are given in Chapter XIV of this volume.

masterly execution, upon a large scale, of the general map, and its striking discrimination of objects, form altogether an achievement of extraordinary merit." In general, it may be said that, while Rennell's work comprised route surveys by compass, checked by astronomical latitudes, Colin Mackenzie produced area surveys, made also by compass, and based in places on a local and minor triangulation. There could be little unification of mapping because no general framework existed. That framework was yet to come in the form of a gridiron of triangulation, from south to north and east to west, consisting of intersecting chains of triangles dividing the country into rectangular areas whose interiors could be filled by minor triangulation and topographical surveying.

But the gridiron system was not evolved in a day. It was preceded by another system which, to some extent, paved the way for it. This was the method initiated by Captain (afterwards Colonel) William Lambton,[1] of the 33rd Regiment, with the support of Colonel Sir Arthur Wellesley, afterwards the Duke of Wellington, under whom he had served in the Fourth Mysore War. As Rennell is known as the "Father of Indian Geography," so Lambton should be styled the "Father of Indian Geodesy," the science which deals with the measurement of the earth.[2] The general public are prone to regard topography—the mapping of a country—as the true work of surveyors, and to look upon the observations of the tides, pendulum observations, and the measurements of arcs of longitude, as of purely academic interest. But this is incorrect. Geodesy is the basis of topography, and without its investigations, a topographical survey would be as untrustworthy as a house without foundations. Recognizing that extensive triangulation was essential for accurate mapping, Lambton planned to cover India with a network of triangles, thereby providing a series of points, fixed with the greatest possible accuracy, which should serve not only as a basis for topographical maps but as a means of affording data to determine the shape and size of the earth.[3]

Guided by the experience of the Ordnance Survey of Great Britain, which had begun its operations in 1784, Lambton set out, in April, 1802, to measure a base line and a small meridional arc near Madras, and he then proceeded to cast a series of triangles over Southern India, being assisted in this work by Lieutenant John Warren, of his own regiment, and Lieutenant Henry Kater of the 12th Regiment.

[1] A portrait of Colonel William Lambton, painted at Hyderabad in 1822 by William Havell, is in the possession of the Royal Asiatic Society in London.

[2] The term "Geodesy" was not invented until Colonel A. R. Clarke, C.B., F.R.S., late R.E., of the Ordnance Survey of Great Britain, published his famous book, entitled *Geodesy*, in 1880. Clarke calculated the figure of the earth in 1866, and his figure is still used in North America. In the British Isles, Sir William Airy's figure is used, and in India, Everest's. Colonel Clarke died in February, 1914. A memoir of him appears in *The R.E. Journal*, Vol. XXXIX, March–December, 1925, pp. 658–665.

[3] *The Oxford Survey of the British Empire*, Vol. VI, p. 322.

In measuring his base, which was about $7\frac{1}{2}$ miles in length, he used a steel chain similar to that employed by the Ordnance Survey, and spent 42 days on the task. When the triangulation had reached as far westwards as Bangalore, a "base of verification" was measured there by Warren, who was delighted to find that the length so obtained differed from the calculated length by less than four inches after triangulating for a distance of 160 miles from Madras. Starting from the Bangalore base, the triangulation was next carried to the west coast; and then a series of triangles, which formed the beginning of what came to be known as the "Great Arc of India," was taken southwards from the Bangalore base almost to Cape Comorin, and, in 1811, northwards towards Central India. The instruments were by no means perfect, but the triangulation across the peninsula from Madras showed that the distance from sea to sea was 40 miles less than that given by the earlier route and area surveys. The first step had been taken towards the attainment of that extreme accuracy which characterizes every result obtained by the modern Survey of India.

Yet Lambton's methods, though superior to those of Rennell, were far from perfect. Time and money were wasted in attempting to cover the whole country with points fixed with extreme precision, and difficulty was experienced in adjusting errors due to faulty observation or defective instruments. But Lambton persevered, and, in spite of failing health, carried his triangulation as far north as the Central Provinces. There, in 1823, harassed by opposition from Government and by lack of money, and worn out by his exertions,[1] he died, at the age of 70 years, close to his great theodolite. In his last report, he wrote:[2] "It would indeed be gratifying to me if I could but entertain a distant hope that a work which I began should at some future day be extended over British India." That hope was fulfilled through the appointment of Everest as his successor.

Lieutenant George Everest, of the Bengal Artillery, and Dr. Voysey, a geologist,[3] had joined Lambton in January, 1818, when the survey operations came to be known as the "Great Trigonometrical Survey of India,"[4] and Everest had begun his work by triangulating between the Kistna and the Godavari in a wild and unhealthy country where he contracted malaria and was obliged to leave India for the Cape of Good Hope in 1820. On his return in 1822, he triangulated eastwards from Bombay to connect with

[1] Lambton, an old man, had often to work single-handed. On one occasion he repaired his 36-in. theodolite himself after it had been seriously damaged by a heavy fall.

[2] *A Memoir on the Indian Surveys*, by Clements R. Markham, 2nd Edition, 1878, p. 71.

[3] Dr. Voysey died in December, 1823.

[4] The name was given by Government to indicate that, unlike previous surveys, this survey would embrace the *whole* of India.

with Lambton's Great Arc Series and, on Lambton's death in the following year, succeeded him as Superintendent. But again his health failed. He is said to have been so racked with malaria that his legs were paralyzed; yet he persisted in his work, lowered into, and hoisted out of, his seat daily by two men when he took observations with an instrument called a "Zenith Sector."[1] At last, having measured a base at Sironj, north of Bhopal, in November, 1824, he was forced to take sick leave once more, and was absent from India until 1830.

The history of surveying throughout the world shows that, during the last 150 years, the methods adopted have been constantly superseded. Most of them have become obsolete soon after their inception. But in the Survey of India three initial steps have proved of such lasting benefit that Engineer officers cannot but acknowledge the debt which they owe to three officers of other branches of the Army who helped to start the Indian Survey on the right lines. These were Colonel Lambton of the Infantry, Colonel Everest of the Artillery, and lastly Colonel Valentine Blacker of the Madras Light Cavalry. Lambton laid down the principle that all India must be mapped upon one homogeneous network of triangulation; he measured base-lines, he instructed Everest, and he carried his triangulation through half the length of the country. Everest, foreseeing that such triangulation, though accurate enough for Great Britain, would generate errors if expanded over the vast territories of India, re-started it on more accurate methods and measured the figure of the earth as had been done already in England. Blacker was the first to grasp the fact that the sheets composing the map of any great area should, to ensure accuracy, be projected so as to lie, when joined together, on a *spheroidal* and not a flat surface, and in 1825 he induced the Government of India to accept this proposition and to put it into practice. The achievements of these three officers proved, even in the early days of the development of India, that scientific enterprise was by no means confined to the Corps of Engineers.

While Everest was in England on sick leave, he employed his leisure in studying the latest advances in surveying and the design of surveying instruments; and when he returned to India in 1830 as Surveyor-General and Superintendent of the Great Trigonometrical Survey, he had the best instruments which could be produced. But he brought with him, also, a most valuable apparatus for the precise measurement of bases, known as "Colby's Compensation Bars," of which he had six sets. These bars were guaranteed to maintain a constant length, for they had been designed to take advantage of the unequal expansion of various metals to eliminate the effects of the

[1] *A Memoir on the Indian Surveys*, by Clements R. Markham, 2nd Edition, 1878. p. 84.

variations of temperature which had so often stultified the results of measurements with chains such as those employed by Lambton. During Everest's absence, the triangulation on Lambton's plan had been extended far eastwards from Sironj towards Calcutta. It was known as the " Calcutta Longitudinal Series," and, during the cold weather of 1831–32, Everest measured a " base of verification " for this series near Calcutta, using the Colby bars for the first time. The superiority of these bars over chains was then so clearly established that they were employed for all subsequent base measurements.

Everest threw himself, heart and soul, into his work, and made sweeping changes in the whole design and system of surveying. He abandoned the previous method of network triangulation on either side of the Great Meridional Arc series, and substituted for it a gridiron system of meridional chains of triangles, spaced at intervals of about one degree apart, and tied together by longitudinal chains which were separated by about five degrees. He introduced new methods of observation by placing, at his points of intersection, mirrors (" heliotropes ") to reflect the sun's rays by day, and coloured lights by night, and he built 17 observation towers to obtain a good field of vision. In these and other ways he reorganized the whole procedure so effectively that his principles were accepted without question for the next 50 years. Assisted by four young officers, including Lieutenant Andrew Waugh, B.E., his future successor, Everest measured a base near Dehra Dun, by means of which he was able to check the triangulation brought up from Sironj. Then he revised part of his work and, on the re-measurement of the Dehra Dun base, had the satisfaction of finding that the difference between its length of about 7½ miles, as measured by the Colby bars, and its length, as computed by the triangulation executed from Sironj more than 400 miles distant, barely exceeded 7 inches ! In 1841, nearly 40 years after it was commenced, the great central meridional arc of the Indian survey, 1,500 miles in length, was completed ; and two years later, Everest was forced, through ill-health, to retire from his responsible post. But his task was finished. He had measured India from end to end : he had determined the shape and size of the earth. On these achievements rests his claim to fame. He was too engrossed with triangulation to take much interest in topography, being content to provide the framework on which others could build. Colonel Sir George Everest, C.B., F.R.S., died in 1866, his name perpetuated by the loftiest mountain in the world.

During the period in which Lambton was triangulating through Southern and Central India, the topographical survey of the country was undertaken by a number of military officers, conspicuous among whom was Captain (afterwards Colonel) Colin Mackenzie, M.E., one of the most energetic of workers, though unfortunately not always

in accord with Lambton. Topographical surveying, the sequel to trigonometrical surveying, does not appeal to the imagination so much as trigonometrical operations on a large scale, yet some reference to its early stages in India is advisable in this narrative. The great primary triangles, and the areas between the chains of triangles, were gradually filled with a network of secondary and tertiary triangles, thus providing sufficient points for detailed surveys with the hand compass.[1] The plane-table, that standby of modern surveying in India, had not yet appeared. The Portuguese territory of Goa, on the west coast, was surveyed in 1811, after Mackenzie had completed his survey of Mysore; and, during the next 18 years, surveys were made of Canara, Coorg, Travancore, Cochin, Malabar, Coimbatore and other southern districts, and of the Carnatic and several eastern districts, so that full materials, based on Lambton's surveys, were prepared for a map of the whole peninsula south of the Kistna. The topographical surveyors of the Bombay Presidency were busy also. Between 1813 and 1820, for instance, a Colonel Monier Williams, and his assistants, covered the whole of Gujarat, Cutch and Kathiawar, and some work was done in Malwa.

In Northern India there were several keen topographical surveyors among the Bengal Engineers who were contemporaries of Lambton. Among these were Major (afterwards Colonel) Thomas Wood, whose brother, Colonel Sir Mark Wood, had surveyed and mapped in the time of Rennell; and in addition, Lieut.-Colonels Francis Wilford, Charles Mouat, Sir James Mouat and Thomas Robertson[2]. It seems, however, that in Everest's day topographical surveying had passed almost entirely into the hands of officers of the infantry, not only in Bengal but throughout India, and this may be explained by the fact that the services of the scientifically-trained Engineers were needed to cope with the greater intricacies of trigonometrical work. In the time of Lambton in 1805, the leading surveyor in the Himalayas and Nepal, and the first to measure and announce the heights of some of the Himalayan peaks was a Bengal Infantry officer—Lieut.-Colonel Charles Crawford; and in 1809 some officers of the infantry surveyed the Ganges from Hardwar almost to its source at Gangotri. There was much activity in Bengal between 1810 and 1814 while Major-General John Garstin, late of the Bengal Engineers, was Surveyor-General, and also during the tenure of Colonel Charles Crawford who succeeded him; and Colonel Colin Mackenzie, late of the Madras Engineers, initiated several surveys while he was Surveyor-General at Calcutta from 1816 to 1821. The mountainous regions between the Sutlej and the Ganges, the provinces of Kumaon and Garhwal, the whole of Bundelkhand, and large areas in Central India, were dealt with during this period.

[1] Triangulation had been applied to topographical surveying in England in 1791.
[2] See Vol. I, Chapter XI, p. 180. Most of these officers served between about 1780 and 1830 and retired as Colonels.

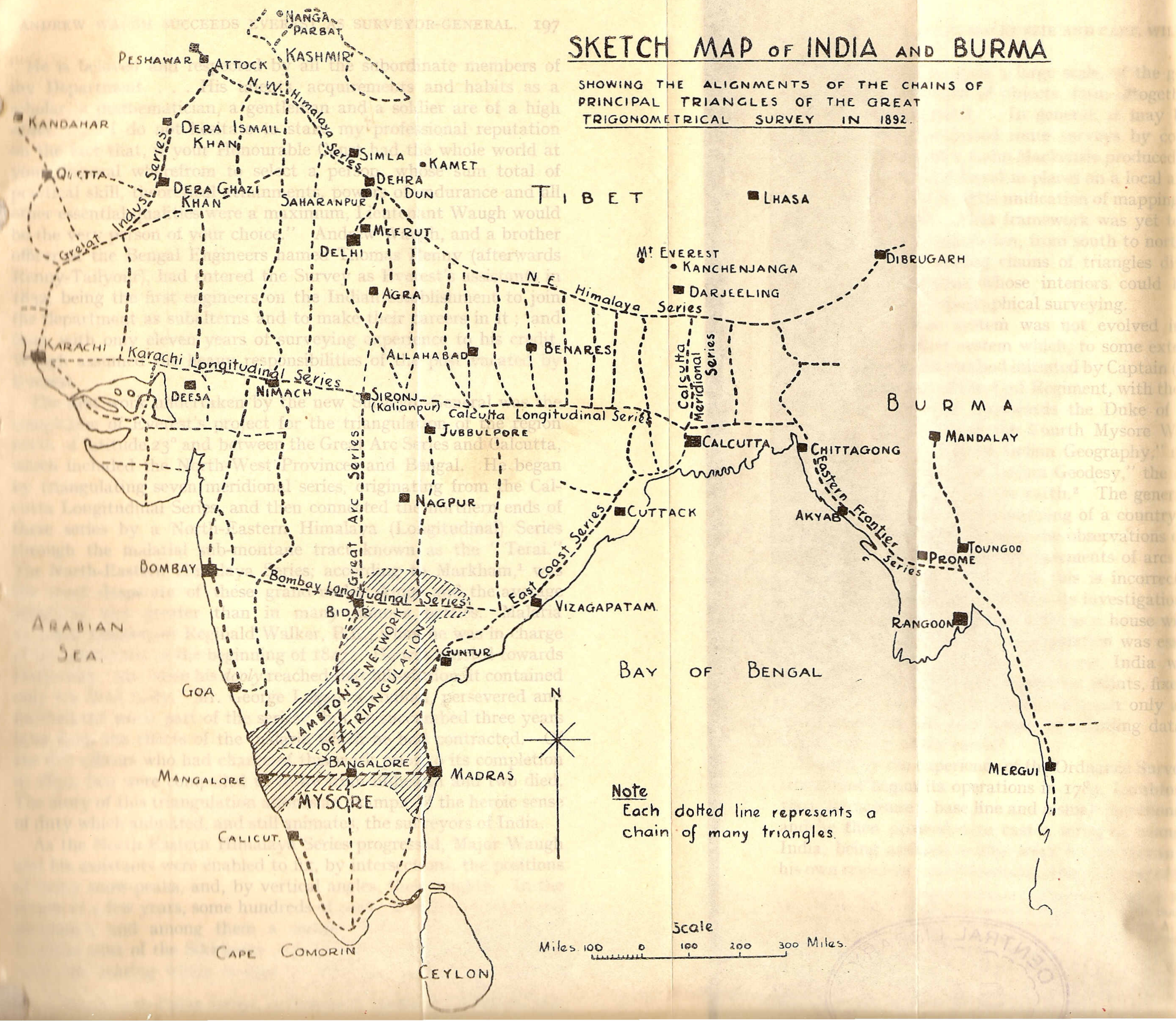
The pioneers in topographical surveying had many exciting adventures and suffered great hardships. Long and weary days in the blazing sun, and longer nights of fever and pain, sapped their vitality; but they were repaid by the sense of freedom, the pleasure of exploring unknown country, and the glorious scenery which often unfolded itself before their eyes. At times, however, their experiences were enough to shake the strongest nerve. It is recorded that when Lieutenant W. E. Morrieson, of the Bengal Engineers, was surveying, with his brother Hugh, in the forbidding swamps and forests of the Sundarbans below Calcutta between 1812 and 1818, a tiger sprang from a branch above their theodolite while one of them was gazing through the instrument. They complained that the theodolite sometimes vibrated "because of the tread of the huge monsters in the jungle." Crocodiles lay in wait for them at the water's edge, and snakes lay coiled in every thicket. Thus, apart from occasional hostile natives, the surveyors of the early nineteenth century had enemies galore.

Owing to the absorbing nature of Everest's duties in connection with the great arc of triangulation, and to difficulties in the organization of his department, topographical surveying languished to some extent between 1823 and 1843. Nevertheless, some useful work was accomplished in the provinces bordering the Himalayas, and three officers explored the Brahmaputra up to the Abor and Mishmi countries. Others carried out explorations along the north-eastern frontier and penetrated northwards in Burma to the region of the Chinese frontier, making rough surveys as they went. Good progress was made also in surveying the Deccan, and in revising the surveys of various southern districts, and maps were produced which were valuable both for military and revenue purposes. But details of these minor activities cannot be recorded in these pages. It must suffice to say that topographical surveying regained its prominence about the year 1847, when Captain H. E. L. Thuillier,[1] of the Bengal Artillery, became assistant in Calcutta to the Surveyor-General, Colonel Waugh.

Lieutenant Andrew Scott Waugh, B.E., who succeeded the famous Everest in 1843, was one of the most brilliant men who ever set foot in India, and he held his appointment as Surveyor-General for no less than 17 years, retiring in 1861 as a Major-General, a Knight Commander of the Bath, and a Fellow of the Royal Society.[2] When Sir George Everest recommended Waugh as his successor, he wrote:

[1] Captain (afterwards Colonel Sir) H. E. L. Thuillier, was the father of Colonel Sir H. R. Thuillier, K.C.I.E., late Royal (Bengal) Engineers, who was Surveyor-General, 1861–80, and carried out a topographical survey of Kumaon. In 1851 Captains R. Smythe and H. E. L. Thuillier published a valuable manual of surveying.

[2] Memoirs of Major-General Sir Andrew Waugh appear in *The R.E. Journal*, Vol. 8, 1878, pp. 48–50; *The Royal (Bengal) Engineers*, by Sir E. T. Thackeray V.C., K.C.B., pp. 158–162; and *Addiscombe. Its Heroes and Men of Note*, by H. M. Vibart, pp. 423–426. He died in 1877.


SKETCH MAP OF INDIA AND BURMA
SHOWING THE ALIGNMENTS OF THE CHAINS OF PRINCIPAL TRIANGLES OF THE GREAT TRIGONOMETRICAL SURVEY IN 1892.
NANGA PARBAT
KASHMIR
PESHAWAR
ATTOCK
N.W. Himalaya Series
KANDAHAR
DERA ISMAIL KHAN
Indus Series
SIMLA
KAMET
QUETTA
DERA GHAZI KHAN
DEHRA DUN
SAHARANPUR
TIBET
LHASA
Great Arc Series
MEERUT
DELHI
Mt EVEREST
KANCHENJANGA
DIBRUGARH
N.E. Himalaya Series
DARJEELING
AGRA
KARACHI
Karachi Longitudinal Series
ALLAHABAD
BENARES
Calcutta Meridional Series
DEESA
NIMACH
SIRONJ (Kalianpur)
Calcutta Longitudinal Series
BURMA
JUBBULPORE
MANDALAY
CALCUTTA
CHITTAGONG
Eastern Frontier Series
NAGPUR
CUTTACK
East Coast Series
AKYAB
TOUNGOO
PROME
BOMBAY
Bombay Longitudinal Series
Great Arc Series
BIDAR
VIZAGAPATAM
RANGOON
ARABIAN SEA
GUNTUR
LAMBTON'S NETWORK OF TRIANGULATION
BAY OF BENGAL
GOA
N
BANGALORE
MADRAS
MANGALORE
MERGUI
MYSORE
Note
Each dotted line represents a chain of many triangles.
CALICUT
Scale
Miles 100 0 100 200 300 Miles
CAPE COMORIN
CEYLON

"He is beloved and respected by all the subordinate members of my Department. . . . His talents, acquirements and habits as a scholar, a mathematician, a gentleman and a soldier are of a high order. . . . I do not hesitate to stake my professional reputation on the fact that, if your Honourable Court had the whole world at your disposal wherefrom to select a person, whose sum total of practical skill, theoretical attainments, powers of endurance and all other essential qualities were a maximum, Lieutenant Waugh would be the very person of your choice." Andrew Waugh, and a brother officer of the Bengal Engineers named Thomas Renny (afterwards Renny-Tailyour), had entered the Survey as Everest's assistants in 1832, being the first engineers on the Indian establishment to join the department as subalterns and to make their careers in it; and thus, with only eleven years of surveying experience to his credit, Waugh assumed the heavy responsibilities of the post vacated by Everest.

The first work undertaken by the new Surveyor-General was the completion of Everest's project for the triangulation of the region north of latitude 23° and between the Great Arc Series and Calcutta, which included the North-West Provinces and Bengal. He began by triangulating seven meridional series, originating from the Calcutta Longitudinal Series, and then connected the northern ends of these series by a North-Eastern Himalaya (Longitudinal) Series through the malarial sub-montane tract known as the "Terai." The North-Eastern Himalaya Series, according to Markham,[1] was the most desperate of these grand undertakings and the average slaughter was greater than in many famous battles. Malaria attacked Lieutenant Reginald Walker, B.E., when he was in charge of the operations at the beginning of 1847. He was hurried towards Darjeeling; but when his *dooly* reached that hill-station, it contained only his dead body. Mr. George Logan, a civilian, persevered and finished the worst part of the series; but he succumbed three years later from the effects of the malaria which he had contracted. Of the five officers who had charge of this work prior to its completion in 1850, two were compelled to retire from ill-health and two died. The story of this triangulation affords an example of the heroic sense of duty which animated, and still animates, the surveyors of India.

As the North-Eastern Himalaya Series progressed, Major Waugh and his assistants were enabled to fix, by intersections, the positions of many snow-peaks, and, by vertical angles, their heights. In the course of a few years, some hundreds of peaks were thus located and measured, and among them a certain "No. 15"—lying about 80 miles west of the Sikkimese peak of Kanchenjanga—from whose crest the tearing winds seemed to blow an everlasting plume of

[1] *A Memoir on the Indian Surveys*, by Clements R. Markham, 2nd Edition, 1878, p. 104.

snow.[1] When the theodolite observations of the year 1856 were analysed, No. 15 was found, by the computers, to be the highest of all the massive giants of the Himalayas; but Waugh prudently refrained from publishing his discovery, for he had met with serious difficulties in the calculation of heights owing to the erratic effect of atmospheric refraction, and accordingly, being in doubt as to the accuracy of his results, he proceeded to study the refraction problem. At length he announced, in 1860, that the height of the nameless peak in Nepal was 29,002 feet,[2] and that it was the greatest which had yet been measured. To mark his admiration of his old chief, he applied for permission to name the peak "Mount Everest," and to this the Government agreed. The question has often been asked, "By whom was Mount Everest discovered?" In the same way, people enquire, "Who regained Delhi for the British in 1857?" The answers should be similar. As Delhi was recaptured during the Indian Mutiny by the united efforts of the whole force under General Archdale Wilson, and not by Baird Smith or Taylor alone,[3] so Mount Everest was discovered by the united efforts of many surveyors and not individually by Waugh. The theodolite observations were taken by several officers, including Captain T. Renny-Tailyour and Lieutenant R. J. Walker, B.E., and the calculations were checked and re-checked by a number of skilled computers. It would be unfair to attribute the discovery to any individual. Andrew Waugh, however, was the organizer, director and scientific adviser in these intricate operations, and consequently it is probable that the credit for the discovery of Mount Everest will be given by posterity to him.

Shortly before Waugh found that Mount Everest was the highest peak in the world, a German scientist, named Herman Schlaginweit, made some observations in the Himalayas and announced that this peak was well known to the Nepalese as "Gaurisankar"; and although the statement was proved, by the Survey of India, to be incorrect, it was accepted in Germany and supported by a British mountaineer who had never visited the Himalayas. However, in 1904, Captain H. Wood, R.E., was permitted to observe Mount Everest from the region of Katmandu in Nepal, and his observations proved that Everest and Gaurisankar were separate peaks, 36 miles apart, and that Waugh had been justified in refusing, as he had done, to remove the name of Gaurisankar from a peak well-known to the Nepalese and to attach it to Mount Everest. It will

[1] The Marquess of Clydesdale, who flew over Mount Everest in 1933, describes the plume as caused by a prodigious jet of rushing winds, flinging a veritable barrage of ice fragments for several miles to leeward of the peak.

[2] The height has not yet been definitely fixed, and the Survey of India adheres to the value 29,002 feet. The most recent investigations have indicated that the height above mean sea level at a point vertically below the peak (*i.e.*, the height above the *geoidal* surface of the earth) is between 29,035 and 29,065 feet, or, say, a mean value of about 29,050 feet. (See Chapter XII p. 220, 221.)

[3] See Vol. I, Chapter XVII, p. 335.

be seen, accordingly, that the identity of Mount Everest was not finally established until half a century after the mountain had been discovered by Waugh and his assistants.[1]

Regarding the procedure adopted in India in naming mountains and other geographical features, Sir Sidney Burrard states[2] that the Survey of India has always tried to record on its maps only such names as are in use *among the people. Of course, there have been* difficulties. For instance, when Megasthenes was at Patna in 300 B.C., he called the river Ganga the "Ganges." Ptolemy copied this, more than four centuries later, in his map of the world, and Europe accepted the name "Ganges" before Rennell went to India. The only geographical name given to a mountain feature in India has been that of Mount Everest, and this because the peak is of world-wide interest and belongs to no particular country or people, for it stands upon the boundary between Nepal and Tibet whose inhabitants have never found a name for it. As a country progresses, new names appear, and these are often accepted by the Survey if given by the people of the locality. A popular English landowner, named Walker, once built a village in Lower Bengal. At his club he was known as "Hookey-Walker," and, during games of tennis, was often addressed as "Hookey." To mark their fondness for him, and without consulting the Survey of India, the natives named the new village "Hookey-Toolah," and the village is now shown as "Huki-Tullah" on the Survey maps. Again, when Lieutenant T. G. Montgomerie, B.E., was observing in the Karakorum Mountains in 1856, he fixed the positions of many snow peaks and, finding that these were nameless, he called them K.1., K.2., etc. Subsequently he discovered that K.2. was the second highest peak in the world,[3] and for many years the Survey of India tried unsuccessfully to find a suitable name for it. Now, however, there is no such need, for not only is the symbol K.2. popular in Europe and America, but the tribes of the Karakorums have included the name "Kaytoo" in their vocabulary![4]

In 1848 Captain Andrew Waugh completed Colonel Sir George Everest's conception of a gridiron of triangulation east of the Great

[1] In 1921, when accompanying the first Everest Expedition, Major H. T. Morshead, D.S.O., R.E., and Captain E. O. Wheeler, M.C., R.E., surveyed from Mount Everest to Gaurisankar and confirmed Captain Wood's results; and, in 1928, when a topographical survey of Nepal was executed, a further confirmation was obtained.

[2] Notes sent to the author by Colonel Sir Sidney Burrard, K.C.S.I., F.R.S., late R.E., in October, 1933.

[3] The height of K.2., as first calculated, was found to be 28,290 feet. The height is now calculated as 28,250 feet. Notes on Mount Everest, K.2., Kanchenjanga, Makalu and other peaks appear in *A Sketch of the Geography and Geology of the Himalaya Mountains and Tibet* (1907), by Colonel S. G. Burrard, F.R.S., R.E., and H. H. Hayden, B.A., F.G.S., Part I, "The High Peaks of Asia," pp. 7–14.

[4] Montgomerie discovered K.2. in 1856 from the summit of the Haramuk peak in Kashmir (16,000 feet high), to which he, and an Indian surveyor, had climbed with a theodolite. A story is handed down by Survey tradition that when he observed K.2. he turned to his recorder and said, "*Babu.* We have shot the Giant." The story is interesting because, as the distance to K.2. was unknown, he could only have inferred the height from the snow-cap, or from solar reflections at sunrise or sunset.

Arc Series, and was then free to extend the operations westwards. This he did by pushing a North-Western Himalaya Series from the Dehra Dun base to Attock on the Indus, where a new base was measured ; by prolonging the Calcutta Longitudinal Series from the Sironj base to Karachi ; by measuring bases at Karachi and other places ; by connecting Attock and Karachi by a Great Indus Series, and by completing the western gridiron by interpolating several meridional series. Progress was greatly delayed by the Indian Mutiny, but the scheme was finished in 1860. A number of military engineers, some of whom were destined to become famous in the annals of the Survey of India, were concerned in these operations. Among them were Lieutenants J. T. Walker, Bo.E., T. G. Montgomerie, and J. P. Basevi, B.E. ; also Lieutenant (afterwards Lieut.-General) J. F. Tennant, a keen astronomer of the Bengal Engineers, and Captain A. Strange of the Madras Cavalry, an expert in surveying instruments. Between 1849 and 1853, Lieutenant J. T. Walker carried out, single-handed, a daring reconnaissance of the dangerous Trans-Indus Frontier from Peshawar to Dera Ismail Khan, and Captain D. G. Robinson, B.E., spent eight years on a topographical survey which covered more than 10,550 square miles between the Jhelum and the Indus.[1] There was much activity, also in the Bombay and Madras Presidencies. But of all the survey work which was originated by Colonel Waugh, the chief was the survey of Kashmir by Montgomerie, which was finished in 1865. While Surveyor-General, Waugh advanced the triangulation of India by no less than 316,000 square miles, an area three times that of the British Isles and, of this, 94,000 square miles were topographically surveyed. When he retired in 1861 he had consolidated and reorganized the department built up by Lambton and Everest, and had imbued every member of it with a share of that enthusiasm which was the dominating feature of his character.

The trigonometrical and topographical survey of Kashmir, under Captain T. G. Montgomerie, B.E., was in full swing, with theodolite and plane-table, when Sir Andrew Waugh retired. Several noted surveyors, such as Captain J. P. Basevi, B.E., Major H. H. Godwin Austen, Captain A. B. Melville and Lieutenant Elliot Brownlow, B.E. (a fine mountaineer who was killed during the siege of Lucknow[2]), received part of their early training among the Kashmir peaks, but interest centres chiefly on their leader, Montgomerie.[3]

[1] Colonel D. G. Robinson, C.B., late B.E., had original gifts which enabled him to represent mountains on paper in ways never before attempted. He served in the Survey of India from 1845 to 1865, being in charge of the Topographical Survey of Central India from 1859 to 1863. In 1865 he became Director-General of Telegraphs, and held this post for twelve years until his death in 1877. (See Chapter XV.)

[2] See Vol. I, Chapter XVIII, p. 362.

[3] Memoirs of Lieut-Colonel T. G. Montgomerie, F.R.S., Royal (Bengal) Engineers, appear in *A Memoir on the Indian Surveys*, by C. R. Markham, 2nd Edition, 1878, pp. 427–429 ; in *The R.E. Journal*, Vol. 8, 1878, pp. 29–31 ; and in *Addiscombe. Its Heroes and Men of Note*, by H. M. Vibart, pp. 568–572.

LIEUT.-COLONEL T. G. MONTGOMERIE, F.R.S., ROYAL (BENGAL) ENGINEERS.

Although Thomas George Montgomerie never rose to be Surveyor General, because the hardships of surveying amid the snows from 1855 to 1865 undermined his health, he has many claims to fame. Apart from his discovery of the peak K.2., he was the first to make topographical surveys of Kashmir and Ladakh. He was the pioneer of glacial surveys in India, and himself observed with a theodolite from the summits of peaks, one of which was more than 20,000 feet above sea-level. His maps, drawn over 70 years ago, are still the admiration of travellers, sportsmen and surveyors, and his contributions to geographical and scientific literature have been of great value. But the work for which Montgomerie is most famous among geographers is his initiation of the system of employing native explorers to make discoveries in those remote regions beyond the northern frontiers of India which British officers could not then reconnoitre without engendering the gravest suspicion and hostility.[1] For this alone he deserves the gratitude of generations of travellers beyond the Himalayan passes. Montgomerie worked for the Survey of India from 1852 to 1875, and died in 1878. His memory is perpetuated in the Corps of Royal Engineers by the Montgomerie Prize, which is awarded annually to an officer of the Corps for a professional contribution to the Corps publications.

When Montgomerie left Kashmir in 1865 he was relieved by Lieutenant T. T. Carter, R.(B.)E. (afterwards Colonel T. T. Carter-Campbell) who surveyed in Kumaon and Garhwal until Montgomerie resumed charge in 1867. Carter had already distinguished himself in the Ambela Campaign of 1863, and in December, 1867, was selected to command a survey party with the expedition to Abyssinia, his assistants being Lieutenants T. H. Holdich and A. E. Dummler, R.E. These three surveyed 6,000 square miles of mountainous country between the Red Sea coast and Magdala, but the effort shattered Carter's health. Nevertheless, he subsequently carried out the chief work on which is based his claim to distinction. This was the North-West Trans-Frontier triangulation, executed in 1869–70, whereby the positions of the principal mountains from Baluchistan to Chitral were fixed, thus rectifying the existing geographical knowledge of Swat, Panjkora, Kafiristan, Chitral and other regions, and enabling his successors to extend their survey operations to Herat in one direction and the Oxus in the other. But the effects of the Abyssinian Campaign brought about Carter's retirement in 1887, and he died in 1900.[2]

The daring and solitary reconnaissance beyond the Indus by Lieutenant J. T. Walker, Bo.E., was followed by his appointment, at the end of 1853, to the Great Trigonometrical Survey, in which he remained for the rest of his service, with the exception of the last

[1] The exploits of some of these native explorers are mentioned in Chapter XIII.

[2] A memoir of Colonel T. T. Carter-Campbell, late R.(B.)E., appears in *The R.E. Journal*, Vol. 30, 1900, pp. 106–107.

three years, during which he was Surveyor-General. When he retired in January, 1884, he had become a General, a Companion of the Bath, and a Fellow of the Royal Society, and thus he takes an honoured place among the famous military engineers of India. During his early career he fought in the Siege of Multan, the Battle of Gujarat, at Delhi in the Indian Mutiny, and in various small campaigns across the Indus; but his future lay in civil employment as a geodesist and surveyor, and in these capacities he proved a worthy successor to Colonel Sir Andrew Waugh, whom he followed as Superintendent of the Great Trigonometrical Survey in March, 1861.[1]

Major J. T. Walker's first tasks were to complete Colonel Waugh's north-western gridiron of triangulation, and to measure a base at Vizagapatam for the connection of the Bombay Longitudinal Series, through Bidar, with an East Coast Series brought down from Calcutta by Captain J. P. Basevi, B.E. Accordingly, in the autumn of 1862, Walker measured the Vizagapatam base with the help of Basevi, Captain Branfill of the infantry, and Lieutenant (afterwards Major-General) W. M. Campbell, R.(Bo.)E., who was destined to become an expert in base-measurement and the observation of longitudinal arcs. Such accuracy had now been attained that the difference between the measured length of the Vizagapatam base, and the computed length after triangulating through 480 miles of country from Calcutta, was only half an inch! Markham records[2] that Walker was most careful to build substantial masonry domes to mark the ends of his new base, as he had found that the natives often destroyed such monuments because they suspected that the structures might cover buried treasure, or feared that they might cast a spell over the district. The East Coast triangulation progressed rapidly. In 1863, Branfill began to extend it from the neighbourhood of Guntur towards Madras, and finally, in 1864, brought the main triangulation of India back to its starting-point at the Madras Observatory after a lapse of 62 years. Thus Walker and his assistants fulfilled the dreams of their great preceptors, Lambton, Everest and Waugh.

But much intermediate triangulation remained to be done before India could be fully mapped, and, during the next few years, a number of engineer officers were engaged in this great work. Lieutenant W. M. Campbell laboured near Bangalore; Lieutenant M. W. Rogers, the first of several Royal Engineers to be appointed to the Great Trigonometrical Survey and afterwards an authority on

[1] Memoirs of General J. T. Walker, C.B., F.R.S., late Royal (Bombay) Engineers, appear in *The R.E. Journal*, Vol. 26, 1896, pp. 77, 78, and in *Addiscombe. Its Heroes and Men of Note*, by Colonel H. M. Vibart, late R.E., pp. 535–537. After Walker's death in 1896 the President of the Royal Geographical Society wrote: "The work done by this illustrious geographer and geodesist during half a century of service is as prodigious in amount as it is valuable in quality. His name ought to be in our list of gold medallists, but he thought that the consciousness of having done his duty was sufficient reward."

[2] *A Memoir on the Indian Surveys*, by C. R. Markham, 2nd Edition, 1878, p. 125.

surveying instruments at the Mathematical Instrument Office in Calcutta, worked at Vizagapatam;[1] and Captain John Herschel, B.E.,[2] a most able mathematician, was employed on longitude observations[3] and in helping Walker, Branfill and Rogers to measure a base, in 1868–69, near Cape Comorin at the southern extremity of the Great Arc Series. Lieutenant H. R. Thuillier, B.E.,[4] extended the Calcutta Meridional Series to the eastern frontier through malarial swamps and, in 1867, began to push northwards a meridional series which was finished by Captain T. T. Carter, R.(B.)E., in 1874. In the Bombay Presidency, Captain (afterwards Major-General) C. T. Haig, R.(Bo.)E., revised the Bombay Longitudinal Series in 1862-64, and surveyed topographically in Gujarat and Kathiawar.[5] Lieutenant H. Trotter, R.(B.)E.,[6] an ardent geographer who ultimately entered the Diplomatic Service, worked on the Malabar Coast in 1866–67; and Lieutenant A. W. Baird, R.E., afterwards Colonel Andrew Baird, C.S.I., F.R.S., the greatest authority of his day on tidal measurements, was employed, for a time, on triangulation after returning from the campaign in Abyssinia.

The brothers George and Charles Strahan, Lieutenants in the Bengal Engineers, should not be forgotten. Both had learnt topographical surveying under Colonel D. G. Robinson in Central India, and Charles was the last Bengal Engineer to be appointed to the topographical branch. George, the elder, worked in the Survey of India from 1859 to 1895. After many years of topographical surveying, he took charge of one of the astronomical parties of the Trigonometrical Survey, and observed for longitude with Captain W. J. Heaviside, R.(B.)E., the last Indian Engineer to be appointed to the Great Trigonometrical Survey, and, according to General Walker, "a born observer." George Strahan and William Heaviside provided a strange contrast when observing at the ends of a longitude arc. Strahan, quick and impatient: Heaviside, patient, methodical and calm. Strahan, indeed, was so impetuous that he would never travel on horseback at any pace except the gallop. "On topographical survey work," said one of his assistants in Rajputana, "his camels were unloaded and his camp pitched at full speed; theodolites were erected and observations taken without pause. He never wanted rest except during sleep." But this whirlwind of the Survey had another absorbing pursuit. He was an excellent artist, and his water-colour landscapes of mountain, river,

[1] Between 1876 and 1880, Captain M. W. Rogers, R.E., did excellent service on the Eastern Sind Series of triangulation.

[2] Son of Sir John Herschel, and grandson of Sir William Herschel, the astronomer.

[3] These are described in Chapter XII.

[4] Afterwards Colonel Sir Henry Thuillier, K.C.I.E., who was Surveyor-General from 1886 to 1894.

[5] Later, when Deputy Surveyor-General, Colonel C. T. Haig was responsible for the extension of the Great Triangulation of India over Northern Burma.

[6] Afterwards Colonel Sir Henry Trotter, K.C.M.G., C.B. A memoir of him, by Colonel Sir Thomas Holdich, appears in *The R.E. Journal*, Vol. XXX, July–December, 1919, pp. 299–300.

forest and desert scenery in India won many prizes and are still much admired. His technique may have been faulty, but he had a true poetic instinct which showed itself also in his devotion to music.[1]

Charles Strahan, the younger brother, served in the Survey of India from 1863 to 1899, and was distinguished as a leading geographer and draftsman of the Robinson school whose maps of Central India, made before 1870, are appreciated to this day. He laboured for many years at Calcutta (1882–94) in charge of the Headquarter Mapping Offices, where his advice on map-drawing and nomenclature was constantly sought by field parties. He was Surveyor-General from 1895 to 1899, and was promoted to the rank of Major-General in 1896. Before his death in 1930 he was the last surviving officer of the Royal (Bengal) Engineers.[2] During the 'sixties and 'seventies many other officers of the Royal Engineers triangulated and mapped the hills and plains of India and Burma. For instance, Lieutenant (afterwards Major-General) R. G. Woodthorpe produced excellent surveys of the Assam-Burma watershed and the Lushai country. Captain J. R. McCullagh was a valuable assistant to Captain George Strahan in surveying Mysore, and Captain (afterwards Colonel) John Hill extended the Great Triangulation from Bengal into Lower Burma between 1877 and 1880; but space does not permit a description of all these activities, which are fully recorded in official publications.

Topographical surveying continued in all parts of India and Burma under the able direction of Colonel H. L. Thuillier as Surveyor-General, and much of the work was executed by parties led by officers of the Indian Staff Corps. But several Royal Engineers were also in the field. The surveys of Lieutenant H. J. Harman, R.E., in the Assam Valley in 1875–76 were far-reaching and valuable.[3] Harman measured the discharges of the Dihang, Dibang and other affluents of the Brahmaputra of Assam, and was the first to suggest that the volume of that river could only be explained on the supposition that it was identical with the Tsan-po of Tibet through the medium of the Dihang. The duties of the topographical surveyors were often hard and exacting. In parts of Rajputana, the survey parties traversed, in 1868, regions which were not only unmapped but unknown; and in the Central Provinces they came upon a tract utterly devastated by a tigress which had killed 50 people and driven the inhabitants from 13 villages.[4] However, making light of danger and sickness,

[1] A memoir of Colonel George Strahan, late R.(B.)E., by Colonel S. G. Burrard, F.R.S., late R.E., appears in *The R.E. Journal*, Vol. XIV, July–December, 1911, pp. 163–186.

[2] A memoir of Major-General C. Strahan, Colonel Commandant R.E., by Colonel Sir Sidney Burrard, K.C.S.I., F.R.S., late R.E., appears in *The R.E. Journal*, Vol. XLV, January-June, 1931, pp. 140–144. It may be interesting to note that there is still (1934) one survivor of the Royal (Bombay) Engineers—Lieut.-Colonel J. H. R. Cruickshank, aged 94 years. There are no survivors of the Madras Corps.

[3] A memoir of Captain H. J. Harman, R.E., by General J. T. Walker, appears in *The R.E. Journal*, Vol. 13, 1883, pp. 112–115.

[4] *A Memoir on the Indian Surveys*, by Clements R. Markham, p. 169.

they plodded steadily onwards in their great task of filling the spaces between the chains of triangulation.

India is a conservative country, and its most successful surveyors are those who try to identify themselves with the outlook of its simple and superstitious people. An official will get every assistance from the people if he is sympathetic: he will encounter every obstruction if he holds himself aloof from their prejudices, hopes and fears. The Indian peasant clings to the habits of his ancestors, and to the names bestowed by them on men and places. Since the days of Rennell and Colin Mackenzie he has given the name "Compāss-*wallah*" to officers of the Survey of India, and the name "Compāss" to many survey stations, and this because Rennell used a compass in Bengal before 1770 and Mackenzie employed one in Mysore in 1800. Seventy-five years later, when the theodolite and plane-table had ousted the hand-compass, Captain George Strahan discovered, to his surprise, that some of the hill-summits in Mysore, which had been fixed by Mackenzie, were still called "Compāss" by the people although Mackenzie had never intentionally entered the name on his maps. In 1905, however, the name "Compass" was found on some of the maps of Mysore and the Central Provinces. The will of the people had triumphed over the objections of map-examiners.

Anyone who climbs Parasnath, a prominent hill south of the Gangetic plains, will find near its summit a Hindu temple close to a survey mark-stone; and, if he talks to the priests, he will discover that the respect for the temple, which has always been shown by the surveyors, has been reciprocated in the care bestowed by the priests upon the Survey's mark, the "mark-stone of the Compāss-*wallah*." In 1894, Captain S. G. Burrard, R.E., was directed to take observations for latitude on the precipitous peak of Gurusikkar, which rises 5,000 feet above the plains of Rajputana. It happened, at this time, that thousands of pilgrims were journeying to Gurusikkar; yet Burrard was allowed to take his observations unhindered, while the temple bell—an old ship's bell—was tolling and the pilgrims were chanting. The crowds fraternized with the surveyors at work on the summit, and were much astonished at seeing a British officer walking round and round a telescope and his Indian staff occupied with their various duties. "Why has the Sahib come here?" they asked. "Why does he look at the stars up here? Has he no stars at Agra or Delhi?" An ancient pilgrim gave his opinion. "There are many soldiers and railways at Agra and Delhi. There is much quiet at Gurusikkar." But all looked finally to the priest for an explanation. "The Compāss-*wallah* Sahib has come here," said he, "because the *Burra Sirkar* (the Government) knows that this place is holy. When he is looking at stars and Heaven, it is good that he should come to this holy place." Simple and childlike; but a fitting tribute to the majesty of the Eastern sky.

Occasionally a survey officer meets with unexpected difficulties which demand the exercise of tact and discretion. "In 1903," writes Colonel E. T. Rich,[1] "I wished to visit the top of a certain hill near a village in Berar as old maps showed that it was the site of a Great Trigonometrical Survey station erected half a century earlier; but the villagers told me that I could not be allowed to visit the hill because the summit was crowned by a very ancient and holy Hindu shrine which had stood there from time immemorial. Nevertheless, I insisted on climbing it, and there I found the shrine, daubed with red ochre, surrounded by flags, and closely guarded by a holy man. As the old triangulation charts showed that the position of the shrine was identical with that of the triangulation station, I took the Brahmin aside and told him privately that I was prepared to risk the gods' displeasure if I could be allowed to displace the shrine for a couple of days, and would pay Rs. 100 if no survey mark were found under the sacred edifice. After a lot of talk, the old man agreed and we removed the stones and flags when, much to the disappointment of my companion, we exposed the survey mark, cut in the solid rock. The mistake had evidently arisen through some Brahmin telling the villagers that the stone cairn, raised over the mark by the original surveyors, was a shrine, and the story then spread until, in the course of half a century, the cairn had acquired great sanctity. I have no doubt that it has since become, once more, an historic shrine and place of pilgrimage."

In 1878 the Great Trigonometrical Survey was renamed the "Trigonometrical Survey," and became, with the topographical branch, part and parcel of the Survey of India. Two years later, Colonel Sir H. L. Thuillier was succeeded as Surveyor-General by that eminent trigonometrical expert, Major-General J. T. Walker. India had then been triangulated from end to end. Lines of levelling had been carried from coast to coast, and the curvature of the earth had been determined by pendulum observations. The topographical field-work of the Survey was being gradually extended beyond the Indian boundaries into Baluchistan, Afghanistan, Persia, Tibet and even Turkestan, and important improvements in the preparation of maps were becoming possible through the invention of colour printing. An organization had been created which was efficient in every department and ably directed by officers of the Royal Engineers.

[1] Notes sent to the author by Colonel E. T. Rich, C.I.E., late R.E., on November 15th, 1933.

GENERAL J. T. WALKER, C.B., F.R.S., LATE ROYAL (BOMBAY) ENGINEERS.

CHAPTER XII.

SCIENTIFIC SURVEYING IN INDIA.

NO better illustration can be given of the extreme care and precision of the methods adopted by the Survey of India than the story of how the longitude of India was fixed. Unlike the Ordnance Survey of Great Britain, which was never troubled with questions of longitude because Greenwich Observatory was one of its stations, the Survey of India started with no zero of longitude, and consequently its officers had to discover exactly how far some selected point in India lay to the east of Greenwich. In 1786, Major Rennell had used, for his maps, a value obtained from navigators and not based on Greenwich; but, about 1800, Mr. Goldingham, the Government Astronomer at Madras, announced that he had fixed the longitude of the Madras Observatory by means of observations of Jupiter's satellites, and that its value was 80° 18′ 3″. This value was adopted in Calcutta when the first Atlas Sheets were prepared in 1809. Twelve years later, Lieutenant John Warren, of the 33rd Regiment, then the Government Astronomer, re-determined the Madras longitude from observations of the moon, and his value of 80° 17′ 21″ was used by Captain Lambton in surveying the Deccan. Thus a complication had already arisen. Goldingham's value was used in the north, and Warren's in the south. Trouble was bound to ensue when the northern and southern surveys met.

From 1823 to 1843 Colonel Everest extended Lambton's triangulation northwards until eventually it overlapped the Atlas Sheets of India drawn in the Mapping Offices at Calcutta; but although Lieutenant Waugh found in 1843, when he succeeded Everest, that two longitude values were in use, he did not trust either sufficiently to adopt it for the whole of India. In 1861 a further difficulty arose. Major J. T. Walker, the new Superintendent of the Great Trigonometrical Survey, learnt that the Admiralty had accepted yet another value, 80° 14′ 19·5″, as the longitude of Madras. The uncertainty with regard to the longitude was a serious hindrance, and it lessened the value of the observations of a total eclipse of the sun taken in 1866 by Major J. F. Tennant, R.(B.)E., at Guntur, and by Captains C. T. Haig, J. Herschel and W. M. Campbell, at Bijapur.

Between 1830 and 1847 Everest had calculated the figure of the earth from measurements along the Great Arc Series in India; and

from 1854 onwards Lieut.-Colonel A. R. Clarke, R.E., of the Ordnance Survey, had laboured on the same problem in England. Clarke arrived at his first result in 1866;[1] but he was engaged on a new determination of the figure in 1870, and asked General Walker to assist him by measuring some arcs of longitude across India from west to east. Accordingly, Walker arranged in 1872 that Herschel and Campbell should observe across India from Madras to Bangalore and from Bangalore to Mangalore, and this they did. But the results were not wholly satisfactory, and Walker would not accept them. Their accuracy seemed to be affected by some fault in the transit instruments, so the latter were returned to England to be tested.

The next step was taken in 1874, when Tennant and Campbell at Roorkee, and George Strahan at Lahore, observed the transit of Venus, while astronomers from England observed it at Suez and determined the longitude of that place, thus providing a stepping-stone between England and India. Two years later, longitude operations were recommenced in India by Campbell and Heaviside, and in 1878–79 they set to work to measure arcs from Suez to Aden, and Aden to Bombay, using electro-telegraphic signals, through submarine cables, to ensure simultaneous observations. By these means they found that the longitude of Madras was 80° 14′ 51·3″—the fourth value accorded to it, but one which was more accurate than any of the preceding ones.

Heaviside and Strahan then proceeded to extend the longitude operations over Bengal and Burma. Grave misgivings soon began to assail Heaviside as to the accuracy of his results, and, as these doubts were shared by General Walker, the two transit instruments were sent once again to England in 1883, and Strahan went with them to test them at Greenwich. In 1885 they were back in India, having been reported as satisfactory, and were then tested by Heaviside with the assistance of a young subaltern, Lieutenant S. G. Burrard, R.E., who was destined to become famous in geodetic circles throughout the world. Although the tests were not reassuring, the instruments were used by Strahan and Heaviside to measure arcs from Agra and Deesa (near the Gulf of Cutch on the west coast) to Multan, Amritsar and Peshawar. But, alas, the errors in longitude were as large as before. No explanation was forthcoming and, for a time, the operations were abandoned. However, they were resumed in 1888 to assist in the solution of a problem which had arisen in the time of Everest. It seems that although Everest had calculated the figure of the earth, and by means of his triangulation, had determined the size of India, he had been unable to locate that country in its correct position upon the earth's figure. Realizing that the remote Madras Observatory would be inconvenient as an origin or basic

[1] Memoir of Colonel A. R. Clarke, C.B., F.R.S., late R.E., by Colonel Sir Charles Close, K.B.E., C.B., C.M.G., F.R.S., late R.E., appearing in *The R.E. Journal*, Vol. XXXIX, March–December, 1925, pp. 658–665.

point for calculation, he had selected Kalianpur,[1] in Central India, for this purpose, but had failed to fix its exact terrestrial position. Accordingly, as this information was urgently needed, Captain S. G. Burrard, R.E., and Lieutenant G. P. Lenox-Conyngham, R.E., were sent in 1889 to observe an arc between Agra and Kalianpur, Burrard working at Agra and Lenox-Conyngham at Kalianpur.

One night at Agra, when Burrard was alone in his observatory tent, puzzling over the hateful errors which had spoilt the longitude observations for sixteen years, the solution came to him in a flash. The errors could be removed by correcting the method of computation. The fault lay in the method of using the instruments rather than in the instruments themselves. The stability of the telescopic sight-lines of the two transit instruments had always been doubted, for the sight-lines seemed to change their position when the instruments were reversed, and the observers had to allow for these changes in making their calculations. Surveyors will appreciate the following technical description of Burrard's discovery, given by Colonel Sir Gerald Lenox-Conyngham:[2] "It occurred to Burrard suddenly that if the object glasses of the collimators[3] were imperfect, or if the collimators were not correctly focussed, the method of determining the collimation error might lead to an erroneous result; but that the effect of that result could be eliminated by using a mean collimation correction for both positions of the instrument. On the following day he set to work to apply this method of computing the collimation correction to some of the old arcs of longitude, and, in the course of a few days, had collected sufficient evidence to prove that his idea was correct. All the large errors of closure disappeared as if by magic, and it became evident that the old observations led to perfectly trustworthy values when the fault in the method of computing was removed. This was a most valuable discovery, and was the first notable example of Burrard's power of analytical research." The intricacies of scientific surveying may be beyond the comprehension of the layman, but the result of Burrard's discovery will be evident to all. It saved the Survey of India the labour and expense of re-measuring and re-calculating those arcs of longitude on which they had been engaged for so many years, and it ensured accuracy and reliability in the future.

In 1892, Colonel Sir H. R. Thuillier, late R.E., the Surveyor-General at that time,[4] was warned that a total eclipse of the sun

[1] Kalianpur, near Sironj, is a scientific point about 160 miles W.N.W. of Jubbulpore, in Lat. 24° N. and Long. 77° 45″ E. approximately. There is no rural population.

[2] Notes by Colonel Sir G. P. Lenox-Conyngham, F.R.S., late R.E., sent to the author on November 19th, 1933.

[3] Subsidiary telescopes used to detect errors in the adjustment of the line of sight of a telescope (*i.e.*, its collimation) when preparing for transit observations.

[4] In 1883, General J. T. Walker had been succeeded as Surveyor-General by Colonel G. C. De Prée, late Bengal Artillery, and De Prée by Colonel H. R. Thuillier in 1887.

would be visible in India in 1898,[1] so he decided that he would finally determine the longitude of India by measuring six arcs across Europe and Persia by the electro-telegraphic method, using the overland telegraph lines for his signals; and he selected, as his observation stations, Greenwich, Potsdam, Teheran, Bushire, Jask and Karachi. New, reversible, transit instruments were made in England and sent out to Dehra Dun. In the autumn of 1894, operations were begun by the measurement of the arcs from Karachi to Bushire, and the observers, Captains Burrard and Lenox-Conyngham, afterwards went to England. Next they measured the arc from Greenwich to Potsdam. Then Lenox-Conyngham went to Teheran, and the Potsdam–Teheran arc was determined; and lastly Burrard travelled to Bushire and the chain was completed. Many difficulties were encountered in this work. The measurement of the long arc from Potsdam to Teheran, in particular, was much hampered by cloudy skies at both ends, and by trouble with the telegraph line through the Caucasus. These elaborate operations ended, however, in an announcement that the longitude of Madras was 80° 14′ 47·1″, and this new value was adopted by the Survey of India in 1900. It seems that, after Burrard had finished his observations in Persia in 1896, there was a serious drought in that country. It was fortunate that this drought did not occur earlier, for the people of Bushire, firmly convinced that Burrard's longitude station was connected in some way with the scarcity of water, promptly destroyed it!

The longitude value, found by Burrard and Lenox-Conyngham, was accepted without question until 1926 when the Surveyor-General, Colonel Sir Edward A. Tandy, late R.E., decided that the value should be tested by the absolutely instantaneous signals of wireless telegraphy. There was no longer any need to observe at the ends of a number of arcs, and, in November, Dr. De Graaff Hunter, Director of the Geodetic Branch, re-determined the longitude of the observatory at Dehra Dun. The result was truly remarkable. "The final value of longitude by the wireless," wrote Sir Edward Tandy in 1927,[2] "has shown that Dehra Dun is only 0·02 seconds of time more easterly than the value obtained in 1894–96 by the method of wire-telegraphy. . . . It must be a source of great gratification to Colonels Sir Sidney Burrard and Sir Gerald Lenox-Conyngham to find that the results of their labours of over 30 years ago have been confirmed within one-fiftieth of a second of time, which corresponds with an actual difference of *less than* 10 *yards* in the relative position of Greenwich and India." The accuracy of a

[1] Two camps were selected and organized, the one at Sahdol, north of Bilaspur, by Captain S. G. Burrard, R.E., assisted by Lieut. H. L. Crosthwait, R.E., and the other at Pulgaon, west of Nagpur, by Captain G. P. Lenox-Conyngham, R.E. At both camps, astronomers who had come from England made successful observations.

[2] Survey of India, General Report, 1926–27, pp. 11 and 12.

result which errs by less than 10 yards in a distance of more than 5,000 miles is almost incredible ; yet in the modern Survey of India, aided by the advances in science which have occurred during the last century, it is not unexpected. The story of these longitude operations is one of unceasing effort crowned in the end by supreme success.

The life of the scientific surveyor and geodesist in India is not spent wholly in the measurement of angles, the observation of stars and the computation of results. When in camp he has occasional relaxation during which he may observe the *real* India, the land of cultivated fields and small villages, or he may indulge in modest forms of sport. There is a popular idea that the survey officer gets the best of big game shooting ; but this is far from true because he often finds himself in a country where there is no big game, or he is too busy or too tired to spend a whole day in its pursuit. Some officers, however, are more fortunate. For instance, Captain Henry (" Job ") Trotter, R.(B.)E., a noted surveyor and explorer, accounted for several lions, many years ago, in Gujarat, and was the first European to shoot *Ovis Poli* in the Pamirs.[1] On one occasion, a very angry tiger was heaved, by an angry elephant, over the *mahout's* head and into the *howdah* in which Trotter was standing ; but such thrilling experiences do not fall to the lot of most survey officers, who must be content with occasional *shikar* after small game, and a week or two after big game when on leave.

" Apart from my work," writes Colonel M. N. MacLeod,[2] " my principal recollections of my first field season are that I wore out three pairs of boots and, for the first time in my career, accumulated a balance on the right side at Cox's. I spent another season in the Salt Range in the Punjab, where the only water not too salt to drink was that which collected during the rains in the ponds beside the villages. When I arrived, this water had everywhere reached the consistency of tomato soup and smelt abominably. My servant had orders to put it through a Berkfeldt ' pump ' filter ; but the water held so much sediment that he found the greatest difficulty in forcing it through, so, being a man of resource, he conceived the bright idea of drilling a small and inconspicuous hole in the porcelain candle of the filter. The result, to him, was splendid—until I discovered the hole ! "

The well-known railway story of the telegram which ran, " Tiger jumping on platform. What to do ? " recalls an appeal which once reached an officer of the Survey of India. " Respectfully I beg to submit," wrote an Indian sub-surveyor, " that I went out for work with Atma Ram and Muhammad Din, *khalassies*, on March 20th.

[1] Memoir of Lieut.-Colonel Sir Henry Trotter, C.B., R.(B.)E., appearing in *The R.E. Journal*, Vol. XXX, July–December, 1919, pp. 299–300.
[2] Notes by Colonel M. N. MacLeod, D.S.O., M.C., late R.E., sent to the author on October 18th, 1933.

On return journey we found a wild buffalo. Atma Ram got afraid and began to run. Naturally the animal grew wild and followed fast upon us. Myself and Muhammad Din then had also to run for our life. As I was most adjacent to the animal, he soon gained upon me, and, in desperate attempt to escape fate, I fell down in a thorny bush. The buffalo was instantly upon me, and made an attack with his forehead. In my utter desperation I tried to caress him, and petted his forehead, and, as luck would have it, the animal got pacified and was tamed. I was thus saved from the Clutches of Death, but God knows who will save my instruments. Under the circumstances it is highly difficult to go out for survey work in the fields. The villagers are willing to tame the beast if they are allowed to do so by magisterial authority, but I shall hope that your Honour will kindly arrange to remove this source of danger." As all India knows, an angry buffalo is as dangerous as a tiger, so no blame attaches to the unarmed surveyor who beats a hasty retreat before him.

C. E. D. Black, in his valuable book entitled *A Memoir on the Indian Surveys*, 1875–1890,[1] states that the principal triangulation of the Indian Survey was designed, from its commencement, to furnish data for employment in the determination of the figure of the earth. But a method, independent of triangulation, by which the spheroidicity of the earth could be estimated, and which would verify the results of triangulation, was proposed in 1864 by Lieut.-Colonel J. T. Walker, R.(Bo.)E. This method provided for observations of swinging pendulums, and it was expected that the results of these observations would throw light on the physical constitution of the earth by showing the intensity of the force of gravity at various points. Owing to the flattening of the earth at the poles, gravity varies in intensity: it is least at the equator, and greatest at the poles. Consequently a pendulum, swinging freely, and making a certain number of vibrations per minute at the equator, will make a greater number as the poles are approached. Thus, by observing the exact number of vibrations made, say, in 24 hours, by a pendulum of fixed length at selected points along a great arc of meridian, the true figure of the earth along that line can be ascertained. To count the vibrations of a pendulum, hour after hour and day by day, would be beyond human capacity and endurance, so this difficulty is surmounted in the following manner. An "observing" pendulum is set up close to a slightly shorter pendulum attached to an astronomical clock. The clock pendulum, being shorter, vibrates at a quicker rate than the observing pendulum; it gains upon it until a maximum divergence is reached, and then, continuing to gain, coincides with it once more. At this instant the observing pendulum

[1] Black continues the history of the Survey of India given by C. R. Markham in his book entitled *A Memoir on the Indian Surveys*, published in 1878.

will have made two vibrations less than the clock pendulum in an interval of time indicated by the clock. The number of vibrations made by the observing pendulum in 24 hours can then be calculated, since the number made by the clock pendulum is known. Such, briefly, is the method of pendulum observation.

A pendulum apparatus, lent by the Royal Society, arrived in India in 1865, and the selected observer, Captain James Palladio Basevi, R.(B.)E., began his work without delay. The Survey of India has had its martyrs, and none, perhaps, more conspicuous than Basevi. He worked with almost superhuman energy; carrying on his observations of pendulum and clock coincidences for ten hours daily for a fortnight at each station, and never leaving his pendulums for more than a few minutes at a time.[1] His nights, also, were largely devoted to star observations. In order to complete his investigations he considered it advisable to swing his pendulums on some of the table-lands in the interior of the Himalayas, at altitudes of from 14,000 to 17,000 feet. For this purpose, early in 1871, he proceeded to Kashmir, and selected a spot called Moré, at an altitude of 15,000 feet, where he completed a most valuable series of observations. From thence he pushed on eastward till he found another suitable spot at an altitude of over 16,000 feet. Here he was taken ill, far from all aid, and died on July 17th, 1871, from the bursting of a blood vessel in the lungs—a martyr to his zeal for the branch of his profession to which he had devoted himself. Basevi succumbed when the prize was almost within his reach, for his work was nearly finished. He would have gone far in his profession: instead, he died for it. A clock tower at Dehra Dun is the Survey's tribute to his memory.[2]

For a period of more than 30 years after Basevi's death, no pendulums were swung in India; but as Colonel Von Sterneck, of the Austrian Geographical Service, had recently invented an improved method and apparatus for observing pendulums, the Government of India decided in 1902 to resume their investigations, and Major G. P. Lenox-Conyngham, R.E., was selected by the Surveyor-General (Colonel St. G. C. Gore, C.S.I., late R.E.) to carry out the work.[3] Lenox-Conyngham proceeded to study the technique of pendulum

[1] *History of the Corps of Royal Engineers*, by Major-General Whitworth-Porter, late R.E., Vol. II, p. 253.

[2] Captain J. P. Basevi, R.(B.)E., was a son of the celebrated architect, George Basevi, who designed the Fitzwilliam Museum at Cambridge and many other structures. Memoirs of Captain Basevi appear in *The R.E. Journal*, Vol. 1, 1870–71 (October), pp. 1–3, by Colonel J. T. Walker, late R.(Bo.)E.; in *The Royal (Bengal) Engineers*, by Colonel Sir E. T. Thackeray, V.C., K.C.B., late R.(B.)E., pp. 225–229; and in *Addiscombe. Its Heroes and Men of Note*, by Colonel H. M. Vibart, late R.(M.)E., pp. 577–581.

[3] The Surveyors-General from 1821 onwards have been as follows:—Colonel Everest, late Bengal Artillery, 1821–43; Colonel Sir A. Waugh, 1843–61; Colonel Sir H. E. L. Thuillier, 1861–80; General J. T. Walker, 1880–83; Colonel G. C. De Prée, late Bengal Artillery, 1883–86; Colonel Sir H. R. Thuillier, 1886–94; Major-General C. Strahan, 1894–99; Colonel St. G. C. Gore, 1899–1904; Colonel F. B. Longe, 1904–11; Colonel Sir S. G. Burrard, 1911–19; Colonel C. H. D. Ryder, 1919–24; Colonel Sir E. A. Tandy, 1924–28; Brigadier R. H. Thomas, 1928–33; Brigadier H. J. Couchman, 1933 (in office).

operations, and, a new apparatus having been made in Vienna according to Von Sterneck's design, he tested it in England by determining the force of gravity at Kew and Greenwich. He then brought the apparatus to India, where he began his observations in 1903 in the same room at Dehra Dun which Basevi had used in 1870, and afterwards observed also at Basevi's stations in Bombay and Madras. Lenox-Conyngham carried out a successful series of observations, during the winter of 1904–05, from Cuttack on the east coast, northwards to Darjeeling and Sandakphu, his highest station being at an altitude of more than 11,000 feet; and, during the next three years, he worked first in the Punjab and Baluchistan, then in the Siwalik Hills and the plains between Dehra Dun and Meerut, and lastly in Southern India. The results of these labours were published by him in 1908 in a valuable professional paper entitled, "The Pendulum Operations in India."[1]

Lenox-Conyngham's work was watched with interest by the scientific world. "The latest instrumental equipment," according to *The Geographical Journal* of 1907,[2] "includes 'half-second' pendulums which are only one-quarter the length of those previously used. A new method (an Austrian invention) has also been introduced for registering the coincidence of beat between the free pendulum and the clock pendulum, the pendulums being no longer swung *in vacuo*. A considerable increase in accuracy of observation has thus been secured. Some of the results are curious. For instance, it was found at Calcutta that the perpetual tremor due to the nature of those alluvial deposits on which the city may be said to be floating, absolutely negatived the value of the observations; whilst, on the other hand, observations taken at Colaba in Bombay were not affected appreciably by the firing of the big guns of the fort in their vicinity."

The pendulum work carried out by Lenox-Conyngham was continued by Major H. Mc C. Cowie, R.E., whose results proved so valuable to International Conferences on Geodesy that the operations were extended widely. Prior to 1912, Major H. L. Crosthwait, R.E., while engaged in the drawing office at Simla, investigated the effects of mountain attraction upon pendulums, plumb-lines and levels at many stations, and published a professional paper in 1912 on the theory of isostasy,[3] in which he calculated the mass of the Himalayas and thus assisted the pendulum observers of India. Three years later, Captain H. J. Couchman, R.E., wrote an interesting professional paper on pendulum operations, in continuation of Lenox-Conyngham's report, but the Great War naturally interfered with all practical

[1] Survey of India, Professional Paper No. 10, dated 1908.

[2] *The Geographical Journal*, Vol. XXIX, January–June, 1907, p. 442.

[3] Isostasy may be defined, in general terms, as a theory that the amount of matter beneath any unit area of the earth's surface is constant, whether that area is at sea-level or at a high altitude.

work. Progress was made, however, when the effects of that cataclysm had vanished; and in 1928, Colonel Sir Gerald Lenox-Conyngham produced, in England, the "Cambridge Pendulum Apparatus," a compact and highly efficient instrument, the details of which are fully described in the *Geographical Journal* of April, 1929. Many results of exceptional interest have been brought to light in recent years by observations made by Brigadier H. J. Couchman, D.S.O., M.C., late R.E., the present Surveyor-General, and by Major E. A. Glennie, D.S.O., R.E., who published a summary of pendulum operations in 1932.

The career of Colonel Sir Gerald Lenox-Conyngham is one which calls for special remark. For 20 years before he published his memorandum on pendulum operations in 1908, Lenox-Conyngham had been engaged in taking scientific observations in all parts of India; but the time arrived when his services were needed for administrative work, and in 1910 he was placed in charge of the Surveyor-General's Office and the Mathematical Instrument Office in Calcutta. Later he became Director of Map Publication, and in 1912 was appointed Superintendent of the Trigonometrical Surveys in which post he remained until he retired in 1921.[1] The knighthood which was bestowed upon him in India, his election in 1918 as a Fellow of the Royal Society, and, after his retirement, his election to a Fellowship in Trinity College[2] and his appointment as Reader in Geodesy in the University of Cambridge, were suitable recognitions of his scientific services.

The Survey of India numbers, among its officers, men of widely diverse gifts and pursuits. Some are scientists, mathematicians, geodesists or astronomers. Others show artistic talent, not only with the brush, but in the production and reproduction of maps by elaborate mechanical processes. Many are fluent linguists, and some are keen amateur archæologists. The greater number, however, specialize in triangulation or topographical surveying, exploring and mapping the open plains and dense jungles of India, climbing her gigantic mountains, and penetrating far into those barren wildernesses which lie in forbidding grandeur beyond the northern passes. History has shown that there is something in the training which the Survey of India imparts to its officers which makes them peculiarly valuable in war. Their work develops not only self-reliance and initiative, but a sense of responsibility. Everything centres on the example set by the leader of an isolated party. As a rule, he is the only European in the small community. He must have powers of organization and observation: courage, determination and endurance. In the ordinary course, he must be precise to the point of pedantry, never satisfied with unchecked work and abhorring the smallest error;

[1] During this period Colonel Lenox-Conyngham officiated for a time as Surveyor-General.

[2] Trinity College took the lead in encouraging the study of geodesy.

yet at other times he must fling theory and practice to the winds to improvise means of rapid reconnaissance when danger threatens. He must understand the innermost workings of the human heart, native prejudices, the ways of officials, the political situation. Surveying is a "key" science, in peace or war. In peace, its exponents are brought into contact with scientific, political and administrative problems—in war, with tactical and strategical problems—and this in a way which must be almost unique among engineers. All the leaders in topographical surveying in Great Britain and India are soldiers, for there is no counterpart to this branch in civil life at home, where the surveyor is one who deals only with roads, buildings or taxes.

Admittedly, an officer of the Royal Engineers who serves for many years in the Survey of India must lose touch with his purely military duties, but he seems to be capable of regaining it with remarkable celerity in peace or war. Captain (afterwards Colonel) the Hon. M. G. Talbot, R.E., after surveying for several years, entered for the competitive examination for admission to the Staff College at Camberley in 1889. He passed at the head of the list of candidates. The records of the Great War show that Royal Engineers recalled to military duty from the Survey of India soon became proficient in field engineering and the command of troops, and their specialized knowledge of triangulation was useful for "sound-ranging" and similar work in the front line. They had been trained in a hard school, whose lessons were a suitable prelude to the sterner tests of a world war.

Many curious, and sometimes unpleasant, adventures come the way of survey officers in India. Mr. C. J. Veale, an officer of the Provincial Service,[1] writes :—

"I had orders to start my triangulation from two stations of the original Great Triangulation in Upper Sind. These stations were hollow brick towers, like factory chimneys, about 60 feet high and designed to support a theodolite. Originally each tower had had, outside it, an earthen embankment to support the observer; but when I reached the first tower, I found, to my amazement, that the earth had subsided almost to the ground in the course of half a century, and I was confronted with 50 feet of chimney with no means of ascent except by erecting a crazy scaffolding of thin poles tied together with grass. This I accomplished, and reached the top, only to find that the scaffolding was too unsteady to be used as a platform for an observer. The only solution was to stand on the chimney-top itself, a ring of masonry about 3 ft. 6 in. in diameter which had also to support my valuable theodolite. Not being a Blondin, I prepared carefully for this ordeal. For a whole week, six hours a day, I sat or

[1] From 1908 to 1932, Mr. C. J. Veale was Professor of Surveying and Drawing at the Thomason Civil Engineering College, Roorkee.

NOJLI SURVEY TOWER NEAR ROORKEE.

One of the lower stations erected by the Great Trigonometrical Survey on the plains of India.

stood on that chimney, reading *Pickwick Papers* to pass the time, until I could balance even in a stiff breeze. Then the theodolite was hauled up and observations began. With my recording book hung round my neck, and men on the swaying scaffolding holding on to my heels, I dodged in and out of the tripod legs, working against time; and, as I swung the theodolite over the side at the end of the operations after the men had descended, the scaffolding collapsed like a concertina.

"On another occasion I was taking an azimuth observation on the boundary between Sind and Baluchistan and had just finished work when cries of terror and the snorting of camels came from the darkness. I ran towards the sounds and found a belated traveller on a camel, attacked by wolves. Lunging at one with my iron-pointed signal staff, and slashing at another with the *kukri* which I always carried in preference to a gun, I managed to drive the brutes off and led the man to the refuge of my camp. He begged me to accept a beautiful astrakhan coat in token of his gratitude, which, of course, I refused to do; but at last, as he was so persistent, I said I would take it, intending to return it on the following morning. The cold was bitter on that desert plain, so I spread the coat over my rug and went to sleep. When I awoke, the traveller whose life I had saved had vanished, taking with him his coat—and mine!"

Such adventures, and others still more surprising and dangerous in the wilds of the Himalayas, go far to explain the ability of the surveyor in India to meet the sudden emergencies of war.

Many years ago, Lieut.-Colonel (now Colonel Sir Sidney) Burrard, F.R.S., R.E., described the scientific activities of the Survey of India as consisting of Principal Triangulation, Levelling Operations, Astronomical Operations, Pendulum and Tidal Operations, Magnetic Survey and Solar Photography.[1] Man's first conception of the earth's figure was a plane. Greek philosophers thought it a sphere. Sir Isaac Newton showed that it must be a spheroid; Colonel Clarke, of the Ordnance Survey, contended that it was a triaxial ellipsoid; and modern geodesy, after encountering great difficulties in testing, in the field, the theories of Newton and Clarke, pronounced it a geoid.[2] Astronomy then desired to know the dimensions of this

[1] Before the Indian Meteorological Department was founded in 1875, several military engineers were concerned also with observations of the barometer, thermometer, hygrometer, direction and force of winds, and rainfall. They carried on the work of Colonel Pearse, who started a meteorological record in Calcutta in 1785; of Major-General T. Hardwicke, who operated later at Dum-Dum; and of Lieut.-Colonel W. H. Sykes, the leading meteorologist in India from 1825 to the middle of the century. These three officers were not Engineers; but John Colvin, William Baker, Henry Durand, Alexander Cunningham, Richard Strachey, John Boileau and other Bengal Engineers were exponents of meteorology, the science which gives such valuable information to engineers, surveyors, mariners and agriculturists.

[2] Article entitled, "An Account of the Scientific Work of the Survey of India," by Lieut.-Colonel S. G. Burrard, F.R.S., R.E., appearing in *The R.E. Journal*, Vol. IV, July–December, 1906, p. 199. The geoid may be defined as the figure of the earth enclosed by the surface of the sea, *i.e.*, by the surface of a spheroid disfigured by protuberances and hollows.

geoid and its departures from a spheroid. It is a great mistake to imagine that the principal triangulation of India was executed for the purpose of measuring the figure of the earth. It was executed to control topography. A triangulation, however, furnishes only the distances apart of the points fixed and their mutual directions. These data are not sufficient for topography, which requires the latitudes and longitudes of the points. To convert the distances and directions of the triangulation into latitudes and longitudes of topography we require a knowledge of the earth's dimensions. A knowledge of those dimensions, as supplied by triangulation and pendulum operations, enabled our surveyors to fix the map of India on to the figure of the earth ; but it failed to provide the solution of a problem which arose in connection with the irregularities, both in form and density, of the earth's crust, and the local attraction exerted by that crust, at various points, on a weight suspended from a thread and known as a " plumb-line."

The plumb-line indicates the direction, though not the force, of gravity, and it hangs always at right angles to a water-surface. It defines the vertical ; and where there is no cause for deflection, the vertical coincides with the normal to the mean figure of the earth. If the plumb-line is deflected by the attraction of mountain masses, or other such cause, the vertical and the normal do not coincide, and the water-surface is tilted with respect to the mean figure. The bubble of a surveyor's level is affected by the same forces, and consequently it may also be tilted. In that case, a surveyor who relies on the bubble will find that, if he determines his latitude by an astronomical observation, his result will not agree with the value deduced from the triangulation. As an example, supposing that Rennell had found, by astronomical observations, the latitudes of Meerut and Dehra Dun, places which are less than 100 miles apart, and had afterwards surveyed between these places, his estimate of their distances apart would have been about one mile too small because he would not have known that at Dehra Dun his level was tilted owing to the attraction of the Himalayas. Similarly, in the case of heights, considerable errors can arise. When Waugh calculated in 1860 that the height of Mount Everest was 29,002 feet, he was obliged to proceed as if the base-plate of his theodolite was parallel to the mean figure of the earth, although he suspected that it must be slightly tilted owing to local attraction.

As early as 1835, Major George Everest had foreseen that the attraction exerted by the Himalaya mountains would present a difficult problem, and his successor found himself confronted with numerous proofs of its existence. At Dehra Dun, at the foot of the mountains, the plumb-line was deflected 37 seconds of arc from the vertical. This large deflection decreased rapidly as the observer journeyed out into the plains ; at Kaliana, 50 miles from the mountains, it had

shrunk to only 7 seconds, while at a distance of 100 miles it had disappeared. In 1852, Captain Waugh showed his results to Archdeacon Pratt of Calcutta, and asked him whether he could discover a mathematical law which would be of practical use to the Survey in this connection. Pratt accordingly took the matter in hand, and in his first paper, which was published by the Royal Society in 1854, he showed that the attraction of the Himalayas ought to produce a deflection of 28 seconds at Kaliana instead of 7 seconds as observed by Waugh.[1] Sir George Airy, the Astronomer Royal, then put forward his theory of "Mountain Compensation." He attributed the discrepancy between Pratt's calculation of 28 seconds, and Waugh's observed result of 7 seconds, to the existence of a deficiency of matter underlying the Himalayas, which deficiency, he explained, would compensate and counteract the attraction of the mountains. Pratt followed Airy in 1858 with an hypothesis that the Himalayas had risen owing to the expansion upwards of the rock underlying them. The two scientists thus furnished what seemed to be a sufficient explanation of the observed deflections.

But when the observations came to be extended, another anomaly forced itself upon the attention of the Survey, for it was found that, all over the plains of the Ganges, at distances from the Himalayas exceeding 100 or 120 miles, the plumb-lines were deflected to the *south* and *away from* the mountains. In 1887, Lieutenant S. G. Burrard, R.E., was directed to take observations in the Central Provinces over the large area between the Narbada and the Godavari, and instead of finding a continuance of the southerly deflections which had been noted between Benares and Agra, he discovered that the plumb-line was now always deflected to the *north*, although there were no visible mountains large enough to cause such deflections. Fourteen years later, having collected all the observed deflections of India for consideration as one problem, he reached three conclusions. He proved that no theory of Himalayan attraction could explain all the observed deflections; that a "Hidden Range," buried in the earth's crust south of the Gangetic plains, was influencing the plumb-lines of Northern India; and that the attraction of the Himalayas was being opposed and masked by that of the "Hidden Range." In 1931, after a lapse of another 30 years, Major E. A. Glennie, D.S.O., R.E., wrote in the Survey Report that gravity data had brought irrefutable confirmation of "Burrard's Hidden Range."

It will be seen that the theory of "Mountain Compensation" had been studied by Everest, Waugh, Pratt and Airy long before Burrard came forward with his theory of a "Hidden Range"; but credit for that advance in geodesy is his alone. As early as 1893, Burrard had written a paper on "Local Attractions in India," which threw new light on the subject; but his paper of 1901 revolutionized all

[1] *Philosophical Transactions*, Royal Society, 1858.

previous ideas, and was welcomed by the Royal Society and many other scientific bodies. The theory propounded in 1901 equalled, some say exceeded,[1] in importance the original discovery by Pratt and Waugh that the deflections of the plumb-line, produced by the mass of the Himalayas, are not as large as calculation shows that they should be, and that therefore that excess of mass in the mountains must be compensated by a deficiency of mass below them. The opinion of the Survey of India was aptly expressed in October, 1919, by Colonel C. H. D. Ryder, C.B., C.I.E., D.S.O., late R.E., then Surveyor-General: "Sir Sidney Burrard's reduction of plumb-line deflections has opened the way for a great further advance in our knowledge of the earth's crust. It is not too much to say that in his paper on "Himalaya Attraction" lies the origin of the development of geodesy in the 20th century."[2] To this tribute was added another from America. "The man of the whole world who was ahead in the study of Isostasy in 1901 was Sir Sidney Burrard," wrote Mr. John F. Hayford, Superintendent of Survey in the United States, in 1924.[3] "He was far ahead, in his thinking on this subject, of anything we had done in the United States up to that time." Thus a military engineer of India led the world in one branch of scientific research.

Colonel Sir Sidney Burrard retired from his appointment of Surveyor-General in 1919, having held it with distinction since 1911. In 1904 he was elected a Fellow of the Royal Society, in recognition of his great eminence as a geodesist; in 1912 he was awarded the C.S.I., and in 1914 he became a K.C.S.I. His contributions to the literature of surveying are too numerous to be recorded in detail: they are prominent in every scientific library. Posterity will view with admiration the character and career of this eminent Royal Engineer.

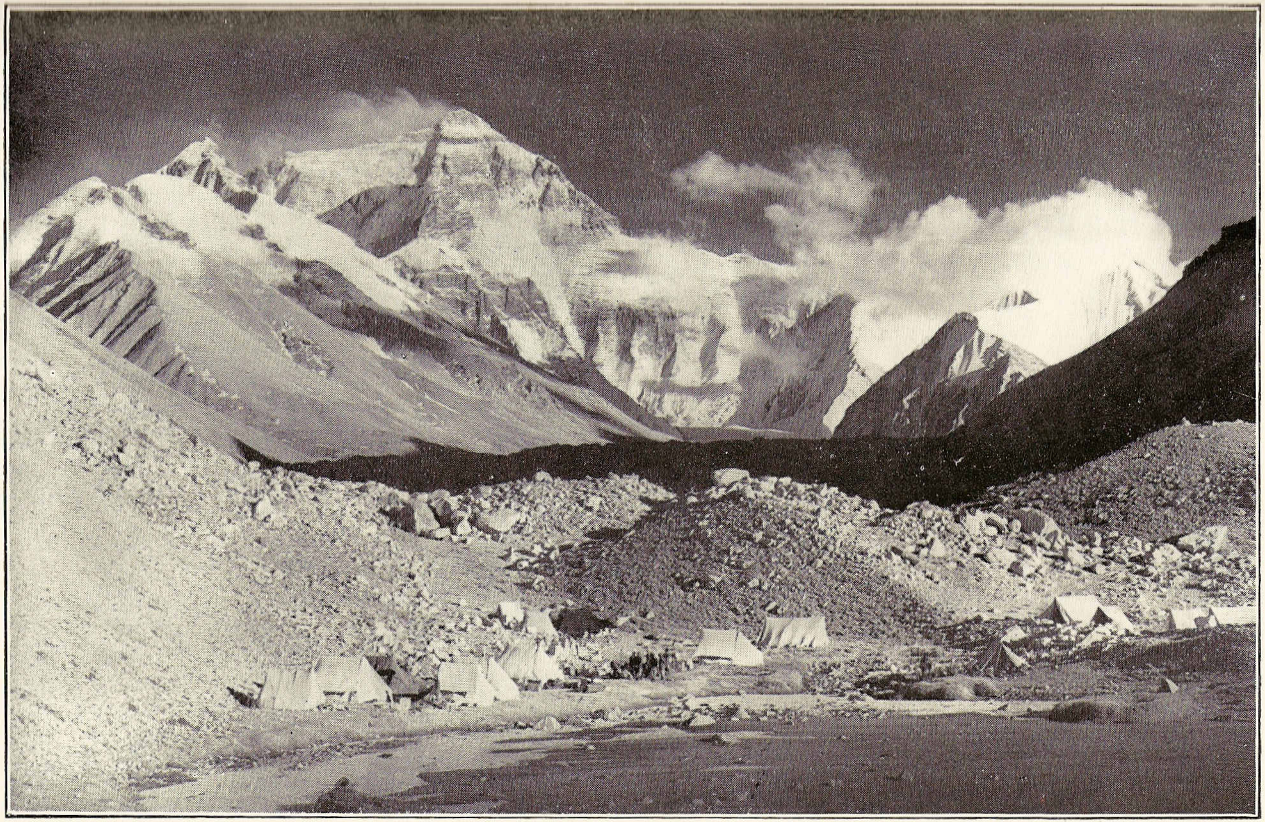
The Survey of India has not as yet succeeded in making a final determination of the height of Mount Everest. The difficulties of the problem are thus explained in a statement by Brigadier H. J. Couchman, D.S.O., M.C., late R.E., the present Surveyor-General:[4] "In a paper published in 1905, Lieut.-Colonel Burrard gave the value of 29,141 feet as the 'most probable value.' This value was obtained by making a more accurate allowance for the

[1] Lieut.-Colonel C. F. Close, C.M.G., R.E., wrote in 1909: "The chief contribution which has been made to geodesy by India since Everest's time is Colonel Burrard's investigation of the intensity and direction of the force of gravity in which he shows that there is a line of excessive density—a 'buried chain of mountains'—underlying the plains of Northern India, 150 miles distant from the foot of the Himalayas." (See *The R.E. Journal*, Vol. IX, January–June, 1909, p. 171.)

[2] A full description of Burrard's discovery appears in a paper entitled "Deflections of the Plumb-line and Gravity Anomalies," read to the Conference of Empire Surveyors in July, 1931, by Colonel Sir G. P. Lenox-Conyngham, F.R.S., late R.E.

[3] Article entitled, "The Establishment of Isostasy," by Mr. J. F. Hayford, appearing in the *Journal of the Western Institution of Engineers* (U.S.A.), September, 1924, Vol. XXIX, pp. 350–362.

[4] As reported in the *Morning Post*, December 6th, 1933.



MOUNT EVEREST

From the Base Camp, Everest Expedition, 1922.

effect of refraction than had been possible when the original value of 29,002 feet was obtained. It made no allowance for the errors caused by the fact that large mountain masses attract the surveyor's plumb-line. If this attraction is taken into account, and the effect of refraction is recalculated as a result of the investigations made by Dr. De Graaff Hunter, a value of 29,149 feet would be obtained. Further investigations may well give yet another value. . . . As it will never be possible to take a line of spirit levelling to the top of Mount Everest, its true height can only be obtained when full information is available as to the difference in height between the geoid and the adopted spheroid at a point vertically below the summit. As far as the investigations of the Survey of India have progressed, the most probable value of the geoidal height of Mount Everest, *i.e.*, the height above the surface of the sea if this were extended inland by canals, is between 29,035 and 29,065 feet. The true value being so uncertain, the Survey of India decline to change the well-known value of 29,002 feet, and can only regret that European geographers have done so."

The main triangulation of India and Burma has been tested by twelve base-lines, each about seven miles in length. At the central point of the system in India a base was measured at Sironj ; and others, at Bidar and Bangalore, were also located on the interior chain. The remaining nine bases were measured at extreme points on the perimeter of the triangulation.[1] It was essential that the exact heights of these base-lines above sea-level should be determined. Originally, many of the heights were obtained trigonometrically by measuring vertical angles along lines leading from the sea to the bases; but afterwards it was realized that greater accuracy would be attainable by running lines of spirit-levelling from tidal gauges on the sea-coast, and gradually spreading a network of such levelling over the whole country. Consequently, Lieut.-Colonel Andrew Waugh initiated the first line of spirit-levelling in 1858, the line being taken by Major J. T. Walker from Karachi to a base at Attock. Other lines followed to the Sironj and Dehra Dun bases, and spirit-levelling was begun also up the Ganges valley. A continuous line of levels soon extended from Karachi to Calcutta. Branch lines appeared, and lines in Central and Southern India, until the network was complete. It had many uses, but one of the most important was that it provided reliable "bench-marks," or datum points, for the use of canal and railway engineers in making their surveys.

The spirit-levelling was conducted with extreme care, three[2] sets

[1] Five bases were located on the central meridian of India, viz., Cape Comorin (1868), Bangalore (1867), Bidar (1841), Sironj (1837), and Dehra Dun (1835). Two were provided to test the triangulation of Sind and the Punjab, viz., Karachi (1855) and Chach (Peshawar) (1854). Three were on the east coast of India, viz., Vizagapatam (1862), Calcutta (1831), and Sonakhoda (1848) ; and two were in Burma, viz., Mergui (1882) and Kengtung (1931).

[2] *A Memoir on the Indian Surveys*, by C. R. Markham, p. 113. Since those days only two sets of observers have been used for precise levelling.

of observers working along the same line of pegs, following each other in close order, but using separate instruments and staves. So accurate were the results that in the first line of levels from Karachi to Attock in the far north, a distance of more than 700 miles, the difference between the height of a point on the Attock base as given by vertical angles from the coast and as found by spirit-levelling was only 3 ft. 2 in. At Dehra Dun the similar difference was 5 ft. 1 in., and at Sironj only 2 ft. 1 in. From the year 1877 onwards, tidal gauges were established, and observations of mean sea-level regularly recorded, at selected points on the coast, but a description of these operations is outside the scope of this brief account.

The problem of carrying lines of levelling across wide rivers confronted the Survey of India for half a century and was solved in 1901 by Captain (now Colonel) H. L. Crosthwait, R.E. In 1857, Captain (afterwards General) J. T. Walker, Bo.E., who was the pioneer of levelling in India, was obliged to carry his line of levels across the Indus at Dera Ghazi Khan where the river was 1¼ miles in width. He was able to avail himself of islands in the river-bed, but even so he had to take longer shots than he considered advisable. Again, in 1863–65, when Captain (afterwards Lieut.-Colonel Sir Henry) Trotter, R.(B.)E., levelled across the Ganges at Allahabad, Mirzapur and Bawah Ghat, he was forced to make shots of over 400 yards in length. Captain (afterwards Colonel) T. T. Carter, R.(B.)E., had to use the ordinary method of levelling when he took a line across the 700 yards' width of the Ganges at Kargola Ghat in 1871. In 1882, however, when Major A. W. Baird, R.E., the distinguished observer of oceanic tides,[1] wished to take his line of levels across the Hugli, where the river was 1¼ miles wide, he introduced the "tide-pole" method by which a pole was erected near each bank and observations of the height of the water on the poles were taken during both rising and falling tides.

After a violent earthquake in 1897, it was decided to carry a line of levels from Calcutta northwards across Bengal, and Captain H. L. Crosthwait, R.E., was placed in charge of the operations, assisted by Lieutenant H. McC. Cowie, R.E.,[2] and an Indian leveller. Cowie was one of the best observers who ever served in the Survey of India. Gifted with a scientific patience which never failed him, he became noted, both in India and Europe, for his astronomical and pendulum observations. Whenever an observation now comes to be reconsidered, it is accepted without question if the name of Cowie is

[1] Colonel A. W. Baird, C.S.I., F.R.S., late R.E., joined the Survey as a subaltern in 1868 after service in Abyssinia. In 1871 he studied the practical details of tidal observations in England, working in close touch with Lord Kelvin and Sir George Darwin. He founded the Tidal Party of the Survey of India in 1873, and erected his first three tide-gauges in observatories in the Gulf of Cutch. Four years later he was again given control of all tidal observations on the Indian coasts and became an authority on such observations.

[2] Lieut.-Colonel H. McC. Cowie, C.B.E., R.E., died at Marseilles in 1925 when embarking for India to assume the appointment of Director of the Geodetic Branch.

attached to it. Crosthwait carried his line of levels across Bengal in 1900 to discover to what extent the level of the plains had been disturbed by the earthquake, and, when confronted by the Ganges at Damukdia, a river $1\frac{1}{4}$ miles wide, decided to observe the difference of level by three methods—by ordinary levelling, by tide-poles, and by vertical angles taken with a 24-inch theodolite. The results convinced him that the method of vertical angles was the most reliable and the quickest means of carrying lines of levels across wide rivers. This method was used in Burma during 1903 by Captain (now Colonel) H. Wood, R.E., and Lieutenant F. B. Tillard, R.E.,[1] in carrying their levelling across the Irrawaddy at Sagaing where the river is 1,100 yards wide.

There remain only a few scientific activities of the Survey to be recorded in this chapter, and not the least important of these is the Magnetic Survey of India, Burma and Ceylon. This was proposed in 1896 by Sir John Eliot, Meteorological Reporter to the Government of India, and by Major-General Charles Strahan, late R.(B.)E., the Surveyor-General, and was supported by the British astronomers who visited India to observe the eclipse of the sun in 1898.[2] As a result, Captain (now Colonel) H. A. D. Fraser, R.E., was sent to England to consult Professor Rücker, of the Royal College of Science in London, who had recently completed a Magnetic Survey of the British Isles with the assistance of Dr. W. Watson of the same college. Six instruments were built and tested in England. Fraser returned with these to India at the end of 1900, and in November, 1901, began his observations to determine declination, dip and horizontal force. Four magnetic observatories, besides that which had long existed at Colaba (Bombay), were established, situated respectively at Dehra Dun, Kodaikanal in the far south, Barrackpore near Calcutta, and Toungoo in Burma. These served as base stations, and observations were made systematically at them and at field stations uniformly distributed over the country at distances of 30 to 40 miles apart. Fraser was engaged in initiating and carrying out this Magnetic Survey until he left the Survey of India in 1905, when he handed over the party to Captain (now Brigadier) R. H. Thomas, R.E.[3] The latter was assisted in the magnetic observations by Lieutenant H. J. Couchman, R.E., and in 1910 he brought the Magnetic Survey of India to a successful conclusion.

Forest surveys, executed for the Forest Department, have often been undertaken by parties of the Survey of India under Royal Engineer officers, although the only officer of the Corps who actually

[1] Lieut. F. B. Tillard, R.E., died of tetanus at Mussoorie in the same year.

[2] *Records of the Survey of India*, Vol. XIX, "The Magnetic Survey of India, 1901–1920," p. 1.

[3] Notes by Colonel H. A. D. Fraser, C.B., late R.E., sent to the author on November 16th, 1933.

served in that Department was Lieut.-Colonel F. Bailey.[1] The work has been chiefly in Southern and Western India, and on the slopes of the Himalayas, and has usually been performed under very unhealthy conditions. For some years prior to 1906, the Forest Department and the Surveyor-General exercised joint control over the survey parties; but latterly, most "reserved" forests have been surveyed by parties under the Surveyor-General alone, the maps being prepared afterwards in a special mapping office at Dehra Dun.

As an army is directed from its general headquarters, so the Survey of India is controlled from the Surveyor-General's Office. This has its adjuncts in the Drawing and Engraving, Map Publication, Lithographic and Photographic Offices, where the results of labours in the field are prepared and issued, and in the Mathematical Instrument Office, where instruments are made and repaired. For the last century the Headquarter Offices of the Survey of India have been divided between Calcutta and Dehra Dun. The Trigonometrical Survey offices were located by Everest at Dehra Dun and Mussoorie when his measurement of the Great Arc of Meridian reached the Himalayas. Dehra Dun then became the scientific centre, and Calcutta the mapping centre. As Surveyor-General, Everest spent most of his time at Dehra Dun; but his successor, Waugh, preferred Calcutta. The definite and final location of most of the headquarters offices in Calcutta took place about 1861 when Colonel Sir H. E. L. Thuillier, the new Surveyor-General, designed and built larger offices in that city, partly because it was the seat of the Supreme Government.

The normal scales of the maps of India are 1 inch and ½-inch to a mile; but smaller scales are also employed, and some areas have been mapped on the large scale of 4 inches to a mile.[2] Until 1850, all the survey maps were printed from stone, and only one small lithographic press existed. Nevertheless, the Survey offices managed to produce many diagrams, forms and illustrations for Government and, until the Mutiny, all the Indian postage stamps. Thuillier added nineteen lithographic presses, and placed Lieutenant James Waterhouse, of the Bengal Artillery, in charge of the Map Publication Office in 1866 as a photographic expert. Three years later, Waterhouse studied cartography in Europe, and returned to India, as the leading expert on the subject, to control the printing of maps until his retirement as a Colonel in 1896. A notable advance occurred in 1900. A new process of photo-zincography was then invented in the Survey Office at Calcutta by Serjeant F. Vandyke, R.E., which

[1] Lieut.-Colonel F. Bailey, R.E., served in the Indian Forest Department, from 1872 to 1890, as a Deputy-Conservator or Conservator, chiefly in the post of Director of the Forest School at Dehra Dun.

[2] Full information regarding the mapping operations of the Survey of India is given in *Records of the Survey of India*, Vol. XII, *Notes on Survey of India Maps*, by Lieut.-Colonel W. M. Coldstream, R.E. (1919). Information is also given in *A Memoir on the Indian Surveys*, 1875–1890, by C. E. D. Black, pp. 221–235.

enabled India, for the first time, to give a lead to Europe in map-production. It is still known as the "Vandyke Process."

While Lord Curzon was Viceroy of India he showed a keen interest in geography. He was well satisfied with the topographical methods and scientific work of the Survey of India, but not with its maps and their production, so he appointed an Indian Survey Committee in 1905 to consider the whole problem, the Surveyor-General, Colonel F. B. Longe, C.B., late R.E., being a member of the Committee.[1] After touring through India and Burma, the Committee made sweeping recommendations, one of which was that an officer of the Ordnance Survey of Great Britain should be sent to India for three years to reorganize the Calcutta offices and bring their processes up to date. The selected officer, Major W. C. Hedley, R.E.,[2] arrived in 1906, and during his deputation to India not only introduced the process known as "heliozincography," but made many other improvements, including the printing of all topographical maps in five colours.

Colonel Charles Strahan, late R.(B.)E., was in charge of the Drawing and Engraving Offices at Calcutta for twelve years until he became Surveyor-General in 1894. He did for the Drawing Office what Colonel Waterhouse had done for the Photo-lithographic Office. Under Strahan the maps of India were unified and expanded to include Ceylon, Tibet, Arabia and Siam; also a new system of spelling geographical names was introduced through his collaboration with Sir W. W. Hunter, I.C.S. When Hedley returned to England in 1908, the charge of the Map Publication Office (Drawing and Photographic Departments) fell to Lieut.-Colonel W. M. Coldstream, R.E., who held this appointment for the next seven years. Among other Royal Engineers who worked in this office were Lieut.-Colonels M. O'C. Tandy[3] and R. H. Phillimore, and Captain (now Colonel) O. H. B. Trenchard. A very able administrator and surveyor in the person of Lieut.-Colonel T. F. B. Renny-Tailyour, R.E., held charge of the Surveyor-General's and Mathematical Instrument Offices at Calcutta from 1904 to 1909, during and prior to the deliberations of the Survey Committee, and after many years of surveying

[1] The Indian (or "Curzon") Survey Committee, which met in 1905, was composed as follows:—Mr. John Miller, I.C.S. (President); Colonel Sir John C. Farquharson, K.C.B., late R.E., late D.G. Ordnance Survey; Colonel S. C. N. Grant, C.B., C.M.G., C.B.E., late R.E., Ordnance Survey; Colonel F. B. Longe, C.B., late R.E., Surveyor-General of India; Colonel F. H. Kelly, C.M.G., late R.E., A.A.G. Army Headquarters' Staff.

[2] Now Colonel Sir Walter Coote Hedley, K.B.E., C.B., C.M.G. Hedley's reforms were the result of an expert organizing power, and were introduced without extra expense. Perhaps his greatest reform was his lesson to the Survey of India that map-reproduction must rank in importance with field topography, and that although topographical surveys of frontiers and mountains are interesting to the public, they are no avail unless followed by efficient reproduction.

[3] Lieut.-Colonel M. O'C. Tandy, R.E., raised the Drawing Office to a high state of efficiency. He had the faculty of retaining in his memory the exact task and progress of each of his numerous draftsmen and engravers. He held charge of this office between 1909 and 1913.

on the frontier between Burma and China.[1] Enough has now been written to show that the Headquarters of the Survey of India have been well served by officers of the Corps.

In a brief history of so complex an organization it is impossible to include the names of all those Royal Engineers who have surveyed and mapped the country. Many officers, such as Colonels S. W. S. Hamilton and J. D. Campbell, Lieut.-Colonels F. J. M. King, H. E. Roome, and Majors O. Slater, T. M. M. Penney and W. J. Norman, have helped, or are helping to maintain the Survey's reputation in the field although no account can be given of their exploits and adventures. Records of individual work must give place to those of the Service as a whole, in peace and war, in the plains of India, in the Himalayas, and in those vast areas which lie beyond them.

During the last few years the Survey of India, in common with every other civil department, has been trying to weather a financial hurricane. " Perhaps no department, not actually abolished, has been hit so hard by the retrenchment policy as the Survey of India," writes a reviewer in *The R.E. Journal* of December, 1933. " It has been reduced, as the latest General Report puts it, to a ' maintenance basis.' The expenditure, which in 1931–32 was Rs. 41½ lakhs, has now been reduced to Rs. 21½ lakhs, and the establishment of superior officers from 63 to 36."[2] The Survey Committee of 1905 recommended that the whole of India should be re-surveyed on a scale of 1 inch to a mile, and estimated that this could be completed by 1930; but the Great War intervened, and the average out-turn fell from 40,000 to 20,000 square miles per annum. In September, 1921, only one-third of the task had been finished; and this although the Secretary of State had agreed in 1913 to the employment of a smaller scale for certain areas, as otherwise there seemed to be little prospect of completion until 1950. In 1922 it was estimated that, even under the modified conditions, the survey could not be finished until 1946.[3] Actually, in 1932, 755,585 square miles, or about four-tenths of the whole area, still remained to be covered. The out-turn increased after the war, and in 1923–24 it reached an area of 65,673 square miles; but at present it is little more than one-half this amount, and many years must pass before a contoured[4] large-scale map of India is available.

[1] Colonel T. F. B. Renny-Tailyour, C.B., C.S.I., late R.E., is the second son of Major Thomas Renny-Tailyour, B.E., who was a close colleague of Sir Andrew Waugh. His elder brother, Colonel Henry Waugh Renny-Tailyour, R.E., was one of the foremost cricketers in England. The latter died in June, 1920. The services of Colonel T. F. B. Renny-Tailyour in Burma are mentioned in the next chapter.

[2] The Survey of India recruits officers from the Royal Engineers and the Indian Army in the proportion of three to one. In future, most of the Indian Army officers will probably be Indians holding King's Commissions.

[3] Article entitled " The Work of the Survey of India," by Colonel Sir Charles Close, K.B.E., C.B., C.M.G., F.R.S., late R.E., appearing in *The R.E. Journal*, Vol. XXXVI, July–December, 1922, p. 270.

[4] In the early maps of the Survey of India, hill features were shown by " hachuring " or form-lines; but contouring was introduced with the use of the clinometer about 1883.

The Department, though reduced in strength, is still very much alive. The principal triangulation has recently been extended to connect with that of Siam, and to strengthen previous work near the Persian border. Chitral, parts of Gilgit, and the northern confines of Burma have been surveyed; and, between 1924 and 1927, a reconnaissance survey of 55,000 square miles of Nepal was executed on a scale of ¼-inch to a mile. New bases have been measured, and others are contemplated. Pendulum, plumb-line and levelling operations have been carried out, and the time is not far distant when the preliminary Gravity Survey of India will be complete.[1]

One modern development of surveying owes its origin to the Great War. This is the science of air survey. The experience of the war, and the improvements in map-making from air-photographs, having stressed the importance and possibilities of such work, the military authorities in India recently guaranteed a subsidy to the Survey of India which has enabled that Department to operate with less financial anxiety, and has strengthened its liaison with the army.[2] One of the survey parties, assisted by the Royal Air Force, is now concerned wholly with air survey, and the maps of large tracts on the North-West Frontier have been extended and revised by this method. Maps can now be made of country, which, for political reasons, cannot be visited, and over which aeroplanes are not allowed to fly. Oblique aerial photographs are taken from a distance. The results are then checked by a few intersected points on the ground, and the contours are sketched in with the aid of a stereoscope. Such maps may not be supremely accurate, but they are greatly appreciated by military commanders, and are sufficiently exact for most purposes. Air survey has also been applied to the preparation of large-scale maps for Revenue purposes in the plains of Bengal. In such ways, the Survey of India keeps abreast of Europe in scientific discovery.

The achievements of the Survey of India in the Great War receive proper recognition in a volume entitled *The War Record*, 1914–1920.[3] This volume was authorized and designed by Colonel E. A. Tandy, Surveyor-General, and compiled by Major K. Mason, M.C., R.E., in consultation with Colonels H. Wood and C. P. Gunter, C.I.E., O.B.E., and other Royal Engineers, and with the help of information supplied by Colonel F. W. Pirrie, C.M.G., C.I.E., of the Indian Army, who was in charge of the Mesopotamian Survey operations until relieved by Lieut.-Colonel C. H. D. Ryder, C.I.E., D.S.O., R.E., in May, 1918. Explorations and surveys were accomplished in the face of many difficulties and in every variety of terrain, from the icy highlands of Central Asia to the waterless deserts of Persia and Arabia. The

[1] Notes by Brigadier H. J. Couchman, D.S.O., M.C., late R.E., Surveyor-General of India, sent to the author on December 4th, 1933.

[2] The army is now closely connected with the Survey of India through the Survey companies and the Frontier Circle, which were formed after the Great War.

[3] *Records of the Survey of India*, Vol. XX, 1925.

territory explored was almost as large as Europe: the area triangulated and mapped was more than twice the size of Great Britain.

Gallant and romantic episodes adorn the pages of the war record: adventures in which most of the leaders were Royal Engineers. There is the tale of how Captain Kenneth Mason guided some 20,000 men to the Dujaila Redoubt in March, 1916, through the blackness of the Mesopotamian night, in their unhappily abortive attempt to relieve the beleaguered garrison of Kut-al-Amara.[1] There are the stories of the adventures of a survey party under Captain W. E. Perry with a mutinous Russian army in Western Persia; of the experiences of Major E. T. Rich in the dash of the "Dunsterforce" to the Caspian; of how Mason's party was the first to cross the desert in motor-cars from Mesopotamia to Damascus; of how Captain C. G. Lewis prolonged the Mesopotamian triangulation to Aleppo, there to connect most accurately with the triangulation carried up from Egypt; of how Major C. P. Gunter kept General Maude's army supplied with up-to-date maps while it was racing to capture Baghdad; and of how Major G. A. Beazeley, having invented a new and valuable method of reconnaissance from aircraft was,[2] shot down and captured in its execution. In almost all these exploits, Indian surveyors took their part, showing a soldierly spirit and a devotion to duty equal to those of their British officers.

As the war spread, the survey officers from India were scattered over the face of the earth; some on military duty with engineer units; others flash-spotting, sound-ranging and triangulating in France and Belgium; and others again reconnoitring and surveying in any or all of three continents.[3] They worked in Salonika, North and South Russia, Italy, Gallipoli, East Africa, Mesopotamia, Egypt, Syria, Persia, and on the shores of the Caspian. One commanded a brigade in North Russia, another led a Persian army. Ten officers of the Survey of India were killed in action, or died on service, during the Great War,[4] and thirteen were wounded. Many casualties occurred in the lower ranks. Such were the contributions of the Department towards victory in the greatest struggle of all time. They form a fitting climax to its record in the frontier wars of India.

[1] See Vol. I, Chapter XXIII, p. 486.

[2] Article entitled "Topographical Air Survey," by Lieut.-Colonel G. A. Beazeley, D.S.O., R.E., appearing in *The R.E. Journal*, Vol. XXXIII, January–June, 1921, pp. 62–77.

[3] Out of an original total of 54 R.E. and Indian Army officers, 27 majors, captains and subalterns, R.E., proceeded on field service between August and October, 1914.

[4] Bt. Major A. A. Chase, D.S.O., Captains R. L. Almond, H. M. McKay, E. B. Cardew, P. G. Huddleston, J. A. Field, G. F. T. Oakes, E. C. Baker and Lieut. V. D. B. Collins, all of the Royal Engineers, and Captain W. P. Hales, M.B.E., of the Indian Army Reserve of Officers.

CHAPTER XIII.

TOPOGRAPHICAL SURVEYS AND EXPLORATIONS.

NATURE has guarded the northern frontiers of India with a mountain barrier, a tangled mass of giant peaks and ridges, unequalled in mystery and grandeur. The Himalayas have attracted generations of explorers, and among these may be found those British and Indian officers and men of the Survey of India whose aptitude for such work, and whose ability to withstand the extreme rigours of high altitudes, have drawn them to this side of their profession. They have penetrated far into the wilds, not for pleasure, but for duty. Yet each would admit that the pleasure is there. Often it has been mixed with pain; sometimes it has ended in death; but volunteers have never been lacking for the most hazardous of all the work undertaken by the Survey of India. The Pamirs, the Karakorums and Himalayas, and the desolate and wind-swept highlands of Tibet in the north and north-west, give place in the north-east to the impenetrable jungles, treacherous chasms, dense mists and roaring torrents of the country towards Burma and China. Amid these obstacles the surveyor has fought his lonely way, and usually with success.

At the end of the eighteenth century the only knowledge attainable of the Upper Himalayas and Tibet came from Chinese sources through certain Jesuit missionaries who had penetrated these regions,[1] and from the reports of a few explorers including George Bogle, the envoy sent by Warren Hastings to Tibet in 1774. An impetus was given to Himalayan exploration by Lieut.-Colonel Robert Hyde Colebrook, 22nd Bengal Infantry, while he was Surveyor-General in Calcutta from 1803 to 1810. His attention was directed to the problem of the source of the Ganges, and, by the middle of 1808, his officers had roughly surveyed that river to its origin at Gangotri.[2] Meanwhile, Lieut.-Colonel Charles Crawford, 25th Bengal Infantry, had been surveying in Nepal, and had discovered the immense heights of some of the Himalayan peaks. Again, while Colonel John Garstin, late B.E., was Surveyor-General from 1810 to 1814, and in the time of his successor Charles Crawford, many route surveys were made by officers marching with troops in the Lower Himalayas; and, after the Nepal War, Captain J. A. Hodgson and Lieutenant J. D. Herbert

[1] A Capuchin Mission was established at Lhasa in 1708, and remained there till 1745.

[2] *A Memoir on the Indian Surveys*, by Clements R. Markham, 2nd Edition, 1878, p. 80. The officers were Captain Webb and Lieutenants Raper and Hearsey.

surveyed the mountains between the Sutlej and the Ganges and then continued into Garhwal, while Captain W. S. Webb surveyed in Kumaon.

The outbreak of the First Burma War led to the collection of much information about the North-East Frontier, and Captain James Bedford, with Lieutenants P. B. Burlton and R. Wilcox, was sent in 1825 to explore the Brahmaputra towards its source. Bedford ascended the Dihang and the Dibang, which go to form the Brahmaputra of Assam, until stopped by hostile Abors and Mishmis, and Wilcox penetrated eastwards to the headwaters of the Irrawaddy in Upper Burma. In the far North-West, Lieutenant John Wood, of the Indian Navy, discovered the source of the Oxus in 1838 and was the first European, except Marco Polo, to reach the "Bam-i-Dunia" or Roof of the World. It is remarkable that almost every explorer of these early days was an officer of the infantry. Presumably the Bengal Engineers were too busy with their civil engineering and surveying work, and with their military duties in the Nepal, Maratha and Burma Wars, to be able to wander far afield.

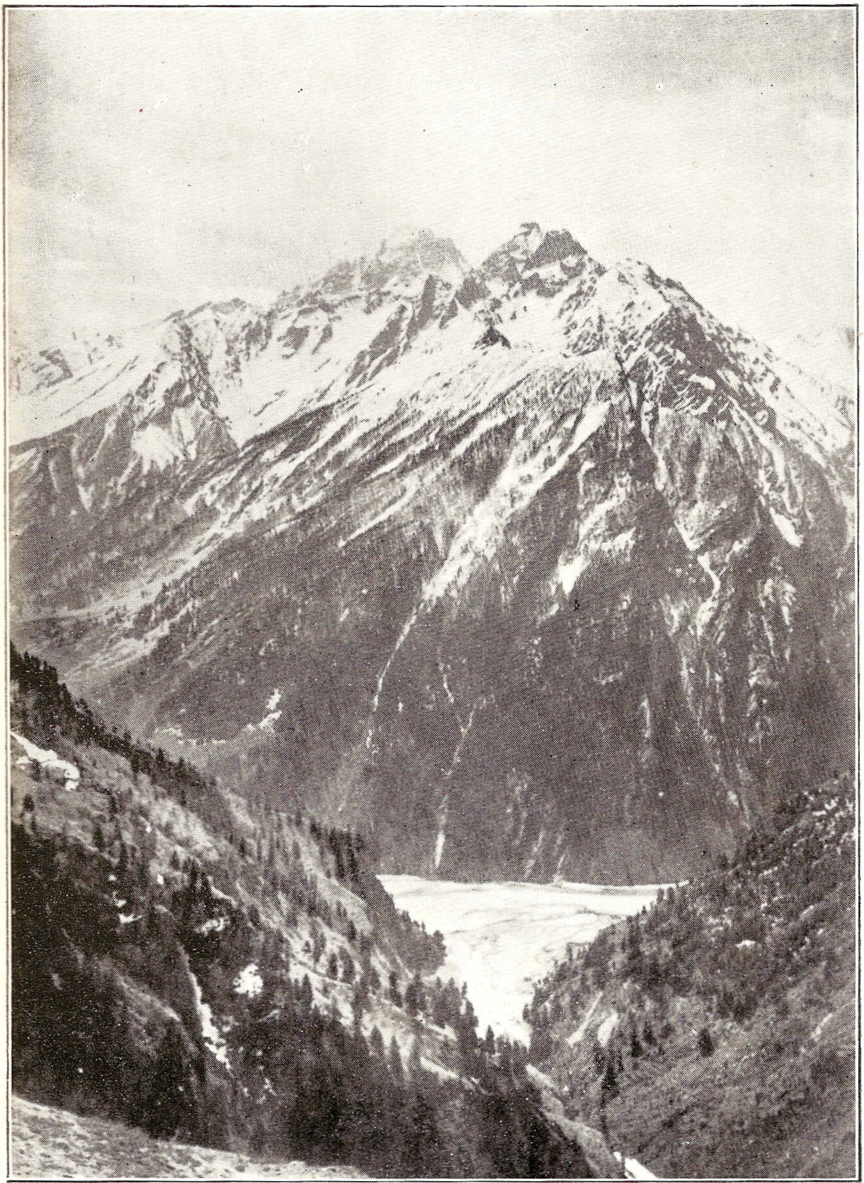
Shortly before, and for some years after, the First Afghan War, a number of able geographers explored the Himalayas. Godfrey Vigne and Hugh Falconer penetrated into Baltistan and Ladakh; Jacquemont and Hugel explored Kashmir; Lieutenant (afterwards Major-General Sir) Alexander Cunningham, B.E., examined the Ladakh region; Dr. T. Thomson, a skilful botanist like many of the others, reached the summit of the Karakorum Pass; Captain A. Gerard visited Spiti and Kunawar; and Lieutenant (afterwards Lieut.-General Sir Richard) Strachey, B.E., and his brother Henry of the Infantry, surveyed in Kumaon and Western Tibet.[1] The valley of Katmandu found an able generalizer in Mr. B. H. Hodgson, for many years the British Envoy in Nepal; and, in 1848, Dr. J. D. Hooker described the geography of the Sikkim portion of the eastern chain.[2] Only two Engineers, Alexander Cunningham and Richard Strachey, figure in this list, and neither of these ever belonged to the Survey of India. Each, however, was a very remarkable man, and as such appears in these pages.

Alexander Cunningham landed in India in 1833 and spent his first 30 years mostly in military duty, following these with 24 years of unwearied research in the wide field of archæology.[3] In 1847–48, after Ladakh had been conquered and annexed by the Maharajah of Jammu and Kashmir, the Government sent a commission to that country. Cunningham was the leader, with Henry Strachey and

[1] The brothers Strachey perpetuated their travels and discoveries in several books, notably: *On the Physical Geography of the Provinces of Kumaon and Gurhwal in the Himalaya Mountains and of the adjoining parts of Tibet*, by R. Strachey, Esq., Bengal Engineers; *Journey to Lake Mansarowa* (1848), by Captain H. Strachey, Bengal Infantry; and *Physical Geography of Western Tibet* (1854), by the same author.

[2] *Himalaya Journal* (1854), by J. D. Hooker (two volumes).

[3] See Chap. XIV.



MALAH SURVEY STATION IN THE GARHWAL HIMALAYAS, 15,088 FEET.

The Survey Station is on the right-hand peak. The other peak is Sri Kanta, 20,120 feet. The river is the Bhagirathi.

Dr. Thomson as his assistants. His book, entitled *Ladakh, Physical, Statistical and Historical,* published in 1854, is still recognized as a geographical classic. In it he traced the Karakorum range with surprising accuracy from the sources of the Gilgit and Yasin to that of the Shyok.[1] Richard Strachey was an enthusiastic and scientific Himalayan explorer who visited the sources of the Ganges very early in his career. He measured the heights of the peaks of Kailas and Kamet with remarkable precision considering that he had no triangulation points, and he was the first to attempt to gauge the rate at which a Himalayan glacier was moving. This he did in the case of the Pindari glacier in Kumaon. In 1849 he took hourly readings of the barometer at heights up to 18,000 feet above sea-level, and for many years he was the chief authority on the altitude of the snow-line in the Himalayas. Yet a third Bengal Engineer who interested himself in the work of the Survey of India, though not as a surveyor, was Henry Yule,[2] who is famous, not only as one of the authors of *Hobson Jobson,* but for his *Cathay and the Way Thither,* for an essay on the geography of the Oxus Valley, and for his translation of *The Book of Ser Marco Polo, the Venetian,* a contribution to geographical history which has never been superseded.

The surveys of Kashmir and the Karakorum by Major T. G. Montgomerie, B.E., from 1855 to 1865, opened a new geographical era in those countries. Assisted by Captain H. H. Godwin-Austen,[3] Lieutenant Elliot Brownlow, B.E., and some civilian surveyors, Montgomerie executed the work in a scientific and methodical manner and, from his surveys, maps were drawn in the Headquarter Office at Dehra Dun and engraved later in England.[4] At this time, Lieut.-Colonel J. T. Walker, R.(Bo.)E., was Superintendent of the Survey at Dehra Dun, and in constant correspondence with his cousin, Sir Clements Markham, the survey historian, who was Geographer at the India Office. Montgomerie's survey party spent each winter at Dehra Dun, where its leader was in close touch with Walker. Indeed, the survey of Kashmir and the Karakorum was almost a family affair, and Government benefited greatly by the harmonious working of all who were concerned in it.

Some reference has been made in Chapter XI to the system, introduced by Montgomerie, under which Indians were trained for exploration in countries which were barred to Europeans. Montgomerie

[1] Article entitled "The Mountains of the Karakoram: A Defence of the Existing Nomenclature," by Colonel Sir Sidney Burrard, K.C.S.I., F.R.S., appearing in *The Geographical Journal,* Vol. LXXIV, No. 3, September, 1929, p. 278.

[2] Afterwards Colonel Sir Henry Yule, K.C.S.I., C.B.

[3] A memoir of Lieut.-Colonel H. H. Godwin-Austen, Bengal Army, appears in *A Memoir on the Indian Surveys,* by C. R. Markham, 2nd Edition, 1878, p. 429. Godwin-Austen served in India from 1852 to 1877, mostly in the Survey of India. He was a very skilful topographical surveyor, a geologist, and an ethnologist, and he did excellent work on the N.E. Frontier after serving under Montgomerie in the North-West.

[4] The maps were engraved for the India Office and published between 1868 and 1872.

began to engage such men about the year 1860, and selected them with great care. Many were called, but few chosen; and, of the chosen, many proved unable to learn their duties. The selected men were taught to make route surveys by taking bearings with a compass and pacing the distances. They learned also to determine latitudes by taking meridian altitudes with a sextant, and to ascertain heights by observing boiling-points with a thermometer. But Montgomerie was careful not to teach them how to make computations, nor were they supplied with astronomical tables. Accordingly, they were unable to fabricate spurious observations. If their work was inaccurate, its faults were soon apparent. The adventures of Montgomerie's "Pandits" make thrilling, and often tragic, reading. One man was sent to Yarkand, the position of which he fixed; a second died, on his way home, in very suspicious circumstances; whilst a third was followed and murdered, on his journey to Chitral, by a man against whom he had a blood feud.[1] However, a Bhutia named Pandit Nain Singh, after two unsuccessful attempts to pass the Chinese outposts on the Tibet border, succeeded in 1865 in reaching the River Tsan-po, where he joined a caravan and accompanied it to Lhasa. Eventually he returned safely to India, and afterwards made other explorations, notably one in 1874–75, which earned him a C.I.E. and a grant of land and money.

Nain Singh's methods were clever. Montgomerie had noticed that the Tibetans always carried rosaries and prayer-wheels, and consequently he arranged that the Pandit should take these with him in order to pass as a Buddhist, and also because they would be useful in surveying.[2] It was necessary that the Pandit should take his observations unobserved, and that he should not be interrupted by questions while he was counting his paces, so he marched, with his servant, ahead of the caravan, or lagged some distance behind it. The sight of his prayer wheel, whirling steadily, was generally sufficient to prevent people from addressing him; but if they had examined the little instrument they would have been surprised. Instead of the usual paper scroll with the Buddhist prayer, "*Om mani Padmi Hum*," the cylinder contained long slips of paper covered with compass bearings, numbers of paces, and other data! The rosary, which should have had 108 beads, had only 100 beads, and every tenth bead was larger than the others. The Pandit carried it in his left sleeve; at every hundredth pace he dropped a bead, and at every thousandth pace, a large bead. Very simple, and very devout! The latitude observations presented greater difficulty than the route survey. Reading the sextant at night, without exciting

[1] Lecture on "The Survey of India," delivered at Chatham on November 27th, 1902, by Lieut.-General C. Strahan, late R.(B.)E., quoted in *Professional Papers of the Corps of Royal Engineers*, Vol. 28, 1902, pp. 141–171.

[2] "Report of a Route Survey from Nepal to Lhasa," by Captain T. G. Montgomerie, R.(B.)E., appearing in *Records of the Survey of India*, Vol. VIII, Part I, pp. 1–77.

remark, was by no means easy; but the Pandit generally managed to do so, though occasionally he had to put the instrument carefully aside after an observation and take the reading secretly at dawn. In a route survey of over 1,200 miles, he made 31 observations of latitude. He carried the mercury, which he needed for this work, in a coconut and a few cowrie shells closed with wax, and poured it into a deep wooden drinking bowl at night to get a sheltered reflecting surface for observation.

Montgomerie's system of training and using Indian explorers was elaborated and improved in later years by Captain (afterwards Lieut.-Colonel Sir Henry) Trotter, R.(B.)E., the very able surveyor who was one of the last officers to join the old Corps of Bengal Engineers.[1] Trotter was appointed as Geographer to the Mission to Yarkand under Sir Douglas Forsyth in 1873–74, and did so well in that appointment that he was awarded the gold medal of the Royal Geographical Society.[2] Unfortunately for the Survey of India, he abandoned survey for diplomacy in 1877. In addition to Pandit Nain Singh, and other men, Trotter took with him to Yarkand a Pandit named Kishen Singh, a first cousin of Nain Singh and known in the Survey as "A.K."[3] Kishen Singh made the most remarkable journeys between 1878 and 1882. He set at rest the vexed question of whether the Tsan-po of Tibet was the upper part of the Brahmaputra of Assam or of the Irrawaddy of Burma. From the northern bank of the Tsan-po he explored eastwards and southwards until he arrived close to the boundary of Assam without crossing the river, thus proving that it could not flow into the Irrawaddy. Then, although within a few miles of home, he was forced by the hostility of the frontier tribes to make an enormous detour to reach India; but he eventually appeared in Darjeeling in November, 1882, and was rewarded by a title, land, money, and gold medals from two geographical societies in Europe. He died in February, 1921, the last survivor of the old Indian explorers.[4] Other solitary explorers followed him, but few of their adventures can be recorded here. These men collected most valuable information, and they showed the world that bravery, enterprise and endurance are not the prerogative of the European.

Occasionally, a European operated in disguise in dangerous country. For instance, Mr. W. W. McNair and an Indian explorer

[1] A memoir of Lieut.-Colonel Sir Henry Trotter, K.C.M.G., C.B., late R.(B.)E., appears in *The R.E. Journal*, Vol. XXX, July–December, 1919, pp. 299–300.

[2] Captain Trotter made the first regular surveys of the Pamirs and Chinese Turkestan, fixing the positions of Kashgar, Yarkand and many other places of lesser note.

[3] Every trained native explorer was known by a letter or letters of the alphabet to conceal his identity.

[4] Pandit Kishen Singh's explorations are recorded by J. B. N. Hennessey in *Records of the Survey of India*, Vol. VIII, Part II, "Exploration in Tibet and Neighbouring Regions, 1879–1892," pp. 215–287; and by C. E. D. Black in his book, *A Memoir on the Indian Surveys*, 1875–1890, pp. 151–158.

started in 1883 on a most adventurous journey into the wilds of Kafiristan, north-east of Kabul, McNair assuming the role of a *hakim* or native doctor, for which purpose he shaved his head, stained his hands and wore native dress. The party consisted of 40 people with 15 baggage animals, and they took with them a prismatic and magnetic compass, a boiling-point thermometer, an aneroid barometer, and a specially constructed plane-table hidden among their camp gear and provisions. The plane-table was in constant use and answered capitally, as in case of surprise the paper was slipped inside and it became a doctor's prescription book. On one occasion McNair was within an ace of being detected through the sudden appearance of four men armed with matchlocks; but in the twinkling of an eye the ruler or sight-vane was run up his long open sleeve, and the pretended doctor was absorbed in hunting for roots![1]

From the year 1872 onwards, a considerable amount of exploration and surveying was undertaken in the forest-clad mountains of the North-East Frontier, and the names of Major H. H. Godwin-Austen and Captain (afterwards Colonel) W. F. Badgley, both of the Bengal Army, and of Lieutenants H. J. Harman and R. G. Woodthorpe, of the Royal Engineers, came into prominence. Expeditions against tribes such as the Lushais, Nagas and Daflas gave opportunities for surveying in war, but the conditions were sometimes more dangerous when all was seemingly tranquil. In 1875 Badgley's party was suddenly beset by Nagas who had entered the camp under the pretence of furnishing supplies. The treacherous savages killed the British Political Officer and 80 men, and wounded 52 others; and the remainder, carrying their wounded, were extricated with great difficulty by Badgley, who was suffering from serious flesh-wounds received in a personal combat with several Nagas.[2]

Henry John Harman was one of the most notable of the early surveyors of the mountains bordering Assam.[3] He served against the Daflas in 1875, and, two years later, surveyed the Garo-Khasi Hills in Assam, with Woodthorpe as his assistant. The Eastern Himalayas were then unexplored, and the course of the Brahmaputra, in and beyond the mountains, was still doubtful, so in 1878 Harman sent an explorer called Nem Singh into Tibet with orders to survey the course of the Tsan-po eastwards as far as he could. Nem Singh followed the river to a place known as Gyala Sindong, north of the Great Himalaya Range, but failed to prove its connection with the Brahmaputra. Indeed, this connection, though practically established as a result of the explorations of Pandit Kishen Singh in 1881–82, was not confirmed until further explorations were made shortly

[1] *A Memoir on the Indian Surveys*, 1875–1890, by C. E. D. Black, 149–150.
[2] *A Memoir on the Indian Surveys*, by Clements R. Markham, 2nd Edition, 1878, pp. 173–174.
[3] A memoir of Captain H. J. Harman, R.E., appears in *The R.E. Journal*, Vol. 13, 1883, pp. 112–115.

before the Great War. The partial failure of Nem Singh's mission induced Harman to despatch a Chinese Lama to Tibet in 1880 with orders to explore the Tsan-po from Gyala Sindong through the Himalayas to Assam. If unable to penetrate the stupendous gorges through which the Tsan-po foams and roars, he was to throw marked logs into the river, and men would watch the Brahmaputra in Assam to see if any of these logs emerged. Harman attached an explorer named Kinthup as an assistant to the Lama, and these two journeyed to Lhasa and then followed the Tsan-po downstream to a point beyond that reached by Nem Singh. Here, however, the unforeseen occurred. The Lama sold Kinthup to the local Jongpen as a slave, and decamped with the proceeds to China! The unfortunate Kinthup did not reach India until November, 1884, after four years' absence.

Harman was no mean artist, and some of his panoramas of the snowy range on the flanks of Mount Everest, as viewed from Darjeeling and Sandakphu, are still in use. When exploring, he showed wonderful courage and devotion to duty. On one occasion he was badly frostbitten at an altitude of 14,000 feet on the border of Tibet; yet, for the next two months, though often in agony, he continued to travel to every point suitable for survey work, sometimes on crutches, at other times on the backs of sturdy Tibetans. He was the first to survey the glaciers of the famous mountain Kanchenjanga, although he had had no experience of Alpine climbing; but this expedition proved to be his last, for he fell ill and soon had to take leave to Europe where he died of tubercular pneumonia in 1883. By his premature death the Survey lost a man with a peculiar aptitude for mountain surveying and an intimate knowledge of the hill tribes of Assam.

Lieutenant (afterwards Major-General) R. G. Woodthorpe, R.E., once an assistant of Harman, was another intrepid explorer who served from 1871 to 1878 in Assam, and on the North-East Frontier, and showed his worth in the Lushai, Garo and Naga Hills. Afterwards he alternated between the North-West and North-East Frontiers, taking part in the Second Afghan War, in which he marched with Roberts from Kabul to Kandahar, and then returning to Assam to serve in the Aka Expedition of 1883–84. After a few years in the Intelligence Branch of Army Headquarters he reverted to the Survey in 1892.[1] Later, he was the first skilled surveyor to examine the Hindu Kush passes from Hunza-Nagar westwards; but his health was failing, and he died in Calcutta, in 1898, from the effects of the malaria which decimates the ranks of forest surveyors. Woodthorpe was an artist, a keen mountaineer, and a noted authority on the tribes of the Assam Hills, and

[1] During 1894–95, Woodthorpe served as Chief Survey Officer on the important Anglo-French Mekong Boundary Commission in N.E. Burma. He was assisted by Lieutenant C. H. D. Ryder, R.E.

he was universally popular because of his genial and generous character.[1]

As the names of Harman and Woodthorpe are connected inseparably with surveying and exploration in the North-East during the 'seventies and 'eighties, so the names of Holdich, Gore, Wauhope[2] and Talbot are linked with the work executed during those decades in the North-West. When Holdich left India in 1898 he was universally recognized as the supreme authority on frontier delimitation and demarcation, and on the geography and tribes of the North-West. There was hardly a corner of accessible ground in that region which he had not seen. He had come into personal contact with almost every tribe and race in Afghanistan, Baluchistan, Turkestan and Persia, and he could probe the innermost workings of the Oriental mind. Gore and Wauhope were masters of the art of triangulating and surveying when marching with armies through a hostile population in Afghanistan. If Montgomerie's career is taken as an illustration of the trigonometrical side of the Survey Department, and Basevi's of the scientific side, Wauhope's career may be selected to illustrate the topographical side.[3] Talbot was noted for his abilities and his soundness of view. All his survey work was done well. He would have been Surveyor-General had he remained in the Department, but he had no such ambition and reverted to military employment.[4]

The North-West Frontier is always a focus of attention: its events are spectacular: its heroes, popular idols. It should be viewed, however, in its proper relation to India as a whole, and its surveying exploits should not be allowed to obscure the excellence of the scientific work undertaken elsewhere. The great topographical work of the Survey of India is the laborious mapping of the whole country, and this is carried out annually without flashes of limelight upon it. We often attach too much weight to some hasty exploration of an Afghan valley, because it meets an immediate military need, forgetting that the ground will assuredly come, in time, under regular triangulation and survey. About 1881, for example, much interest was excited by Gore's map of Peshin and the Khojak; but these areas have long been included in the regular Survey of India, and the attention which they attracted was ephemeral only. Such matters must accordingly be viewed in their proper perspective. To

[1] A memoir of Major-General R. G. Woodthorpe, C.B., late R.E., appears in *The R.E. Journal* of July, 1898.

[2] Originally Wahab.

[3] Notes by Colonel Sir Sidney Burrard, K.C.S.I., F.R.S., late R.E., sent to the author on September 4th and October 28th, 1933.

[4] Remarks by Colonel Sir Sidney Burrard, quoted in a memoir of Colonel the Hon. Milo George Talbot, C.B., appearing in *The R.E. Journal*, Vol. XLVI, January–June, 1932, p. 142. Talbot had an intimate knowledge of Persian which made him valuable beyond the N.W. Frontier. He did excellent survey work, not only in Afghanistan, but in Waziristan, Baluchistan and Persia. He entered the Staff College in 1889, and afterwards went to Egypt and the Sudan.

CHECKING A PLANETABLE.

one man falls the exploration of the wilds beyond the border; to another, a part in the triangulation and mapping of vast areas in India; to a third, scientific pursuits such as the investigation of the earth's crust; to a fourth, the elaborate processes of map reproduction; to a fifth, the co-ordination of the whole or a portion of the work. None is greater nor less than another. All represent the Survey of India.

The career of Colonel Sir Thomas H. Holdich, K.C.M.G., K.C.I.E., C.B., late R.E., affords a shining example of efficiency and enterprise in Frontier surveying.[1] Starting as a temporary assistant with the Bhutan Field Force in 1865–66, Holdich soon afterwards entered the Survey of India and remained in it for 32 years, during which he saw further active service in Abyssinia (1868), in the Second Afghan War (1879–80), against the Mahsud-Waziris (1881) and in the Zhob Valley (1890). When he first set foot in Quetta, in the early days of Robert Sandeman, very little was known of Baluchistan beyond parts of Kalat and the Pishin plain. The Afghan War changed all this. For the first time, Royal Engineer officers, with trained staffs of Indian assistants, made accurate geographical surveys with the advanced forces instead of mere rapid military sketches.[2] Lieut.-Colonel W. M. Campbell, R.(Bo.)E. with Captains W. J. Heaviside, R.(B.)E. and M. W. Rogers, R.E., triangulated up to Kandahar; and when that place was taken in 1879, Holdich surveyed towards the Helmand, Girishk and Kalat-i-Ghilzai.[3] In the second phase of the war, he surveyed through the Khaibar Pass,[4] was besieged with Roberts in Sherpur outside Kabul,[5] and marched with him to Kandahar. In 1881, Holdich was the first white man to climb Shuidar, the second highest peak in hostile Waziristan. Afterwards he devoted himself, for a time, to training Indian explorers as Montgomerie and Trotter had done. While plane-tabling on active service against the Khiddarzai clan in Baluchistan in 1883, he discovered a route to the top of the Takht-i-Sulaiman, and by leading troops up this path, enabled them to capture the enemy's position with negligible loss, thus demonstrating the value of surveyors in frontier warfare.

His first real opportunity for gaining distinction, however, came

[1] A memoir of Colonel Sir T. H. Holdich appears in *The Geographical Journal*, Vol. LXXV, No. 3, March, 1930, and is reprinted in *The R.E. Journal* of June, 1930, with additional remarks.

[2] *A Memoir on the Indian Surveys*, 1875–1890, by C. E. D. Black, p. 139.

[3] Sketch Map III at the end of this volume shows these and other places on the N.W. Frontier and in Afghanistan.

[4] Another survey party under Captain R. G. Woodthorpe, R.E., accompanied General Roberts by the Kurram Valley. Other survey officers who served in the war were Captain (afterwards General Sir) E. P. Leach, V.C., Captain Charles Strahan, and Lieutenants Hon. M. G. Talbot and R. A. Wauhope.

[5] While surveying in Afghanistan, Holdich discovered that, according to local tradition, it was on the summit of the snow peak of Kund overlooking Lughman from the region of Kafiristan that Noah's Ark rested after the Flood. The valley of Dar-i-Nur on the border of Kafiristan still bears Noah's name.

to Holdich in 1884, when he was attached, as Survey Officer, to the Russo-Afghan Boundary Commission which was appointed to adjust the boundary between Turkestan and Afghanistan after a Russian scare. He was recalled from a survey in the Zhob Valley, where he was working with Lieutenant R. A. Wauhope, R.E., and then proceeded to triangulate through Western Afghanistan from the Helmand as far as the Hindu Kush near Herat, and along the Russian frontier. In this he was ably assisted by Captains St. G. C. Gore[1] and the Hon. M. G. Talbot of his Corps, and their combined efforts during 1885 resulted in surveys which are still reproduced in text-books as examples of how such work should be done. Their mapping of the regions of Afghan Turkestan and the Oxus added greatly to the world's knowledge of Central Asian geography, and the frontier which they marked is accepted to this day.[2] After the completion of this important task, Holdich was engaged for a few years in organizing the surveys of Baluchistan, and of Mekran as far as Jask and Bandar Abbas at the entrance to the Persian Gulf, the actual triangulation being done mostly by his assistants Talbot and Wauhope.

The years 1885 to 1896 were remarkable for the number of boundary settlements which were undertaken in Asia and, as Superintendent of Frontier Surveys, it fell to Holdich in 1894 to begin the demarcation of the boundary between India and Afghanistan which was negotiated by Sir Mortimer Durand with the Amir Abdur Rahman and came to be known as the "Durand Line." Holdich was against this project. He objected to fixing an easily penetrable boundary behind the territories of independent tribes, a line which would not prevent intercourse between these tribes and the Afghans, but which the British, nevertheless, could not cross. He preferred the policy, now accepted, of strong British posts, near the Afghan frontier, with good communications in rear. However, he set out, with Lieutenant W. M. Coldstream, R.E., to demarcate the northern section from Landi Kotal, in the Khaibar Pass, to the Hindu Kush Range. Wauhope, assisted by Captains C. L. Robertson and P. F. J. Macaulay, R.E., carried the line through Waziristan; and Captain R. J. H. L. Mackenzie, R.E., with Mr. G. P. Tate, prolonged it through Baluchistan. On November 3rd, 1894, the Waziris attacked the British camp at Wana and Macaulay was killed; but the survey work went steadily on and the Durand Line was duly completed and marked with pillars.

Immediately after his return from Chitral, Holdich was appointed

[1] Colonel St. G. C. Gore, C.S.I., late R.E., retired in 1904 after five years as Surveyor-General, and died in 1913. After his work on the Russo-Afghan Commission, he returned alone from Meshed to Bandar Abbas to survey part of Persia. In 1886–87, at Dehra Dun, he drew the maps of the Afghan Boundary.

[2] For his services on the Russo-Afghan Boundary Commission, Major T. H. Holdich, R.E., was promoted Brevet Lieut.-Colonel, and was awarded a gold medal by the Royal Geographical Society.

Chief Survey Officer on the Pamir Boundary Commission of 1895, with Wauhope once more as his assistant. The Commission was required to determine the Russo–Afghan boundary along the northern edge of the narrow Wakhan strip of Afghan territory which crosses the Pamir Plateau. The British delegates met the Russians in July; the line was marked; the Great and Little Pamirs were triangulated and mapped; and, by observations of known peaks of the Himalayas to the south, the Pamir triangulation was joined to that of India. So accurate was this junction by the method of "resection" that the deliberate geodetic connection made in 1912–13 by Captain H. G. Bell and Lieutenant K. Mason, R.E., with modern instruments and careful triangulation, showed that the position of a place called Kizil Rabat, in the Great Pamirs, as fixed by Holdich and Wauhope, was only 135 yards in error. Holdich gave the chief credit for the work to his assistant. "The success of the Pamir Triangulation of 1895," he wrote,[1] "was due to Wauhope's capacity for climbing great heights rapidly, and to the promptness with which he observed rounds of angles from the summits."

While the Pamir Commission was at work, the Shah of Persia agreed to a settlement of the boundary between his country and Baluchistan, and hardly was Holdich back from the Pamirs in 1895 than he was despatched as Chief Commissioner on the Perso–Baluch Boundary Commission, with Wauhope, now a Brevet Lieut.-Colonel, as Chief Survey Officer.[2] Their task was to select and survey the boundary from the Mekran Coast to the peak of Koh-i-Malik Siah, the south-west point of Afghanistan, which had been intersected by Wauhope himself in 1884.[3] By the end of March, 1896, the boundary had been marked for a distance of 300 miles, and soon afterwards Colonel Holdich was made a K.C.I.E. Then came the Tirah campaign of 1897–98, with Holdich as Chief Survey Officer, and Wauhope, of course, as his senior assistant; but Holdich was obliged to retire in February, 1898, on reaching the age of 55 years, and Wauhope stepped into his shoes. Nevertheless, this did not end Holdich's connection with surveying. Having been invited to settle a boundary between Chile and the Argentine, he visited South America in 1902, and returned there in the following year, with Major H. L. Crosthwait, R.E., and other officers, to mark the selected line. He died in November, 1929, the most conspicuous of the celebrated surveyors of the Indian frontiers.

Much has been written already on the subject of the exploits of

[1] *The Indian Borderland*, by Colonel Sir T. H. Holdich, K.C.M.G., K.C.I.E., C.B.

[2] One of the Assistant Commissioners was Captain P. M. Sykes (now Brig.-General Sir Percy Sykes, K.C.I.E., C.B., C.M.G., the eminent authority on Persia).

[3] The exact position of this important peak, the tri-junction point of Persia, Baluchistan and Afghanistan, was fixed by Mr. Tate in 1896, and the peak was made a principal station of the Great Trigonometrical Survey of India by Captain C. M. Browne, R.E., when triangulating in 1908.

Colonel Robert A. Wauhope,[1] C.B., C.M.G., C.I.E., late R.E., a past-master of the art of surveying in the midst of the hostile tribes beyond our borders. A born geographer and linguist, a strong and keen mountaineer, he seemed to have been specially designed for the arduous tasks that were allotted to him through life. There are survey stations in Southern India which are still known as Lambton's stations; and there are others in Northern India which have, for over a century, been venerated as Everest's stations. Wauhope's surveys were carried out in wilder countries. There are many important mark-stones and cairns on the hills of Asia, from Arabia to the Pamirs, which will be known to posterity as Wauhope's stations.[2]

A few years after Holdich's retirement the question of the demarcation of a proper Anglo-Turkish boundary in South-West Arabia was forced on the Indian Government by disputes among the Arab tribes of that region. It became necessary to reach an agreement with Turkey as to which tribes were to be governed from Constantinople and which from Aden, and a line of pillars was needed to mark the boundary through country which was unmapped. Wauhope was appointed in 1902 as the Chief British Commissioner, with Lieutenant M. O'C. Tandy, R.E., in charge of the survey operations, and he remained in Arabia, on political and diplomatic work, until the boundary was defined in May, 1904. Great difficulties were encountered, and were overcome by patience and persistence. The British survey marks were often destroyed by the Arabs, and occasionally by the Turks. The Arabs fought among themselves, the Turks wrangled and procrastinated and, as early as December, 1902, Tandy was attacked and wounded. Wauhope's health suffered, and he retired from the army in 1905. Nevertheless, he offered his services in the Great War and, as Intelligence Officer for South-West Arabia, voyaged up and down the Red Sea from August, 1915, to June, 1916, when he rejoined the Survey in India and assisted in the preparation of war maps until hostilities ended. He died in 1921, leaving behind him a wonderful record, for he had served in no less than eleven campaigns.[3] Thus passed a man whom *The Times* described as "A Maker of Maps." Rather should he have been styled "A Maker of Empire."

The North-West Frontier of India has witnessed many strange scenes; but one of the strangest was that which occurred on a lone mountain summit more than 15,000 feet above sea-level. Two young civilian surveyors, both Europeans, were at work on this

[1] Students of survey history may not always identify Wauhope under his earlier surname of Wahab. He changed his name in middle life. He is shown always as Wauhope in these pages in order to avoid confusion, but in Vol. I he appears as Wahab.

[2] Memoir of Colonel Robert Alexander Wauhope, appearing in *The R.E. Journal*, Vol. XXXV, January–June, 1922, pp. 151–166.

[3] Afghanistan, 1878–79; Rumpa, 1879; Mahsud Waziri, 1881; Zhob Valley, 1884; Hazara, 1888; Miranzai, 1891; Hazara, 1891; Isazai, 1892; Waziristan, 1894–95; N.W. Frontier, 1898; and the Great War (Arabia and India), 1915–1918.

peak, one observing through a theodolite whilst the other recorded the observations. Suddenly the observer felt himself gripped from behind. His companion had become a raving lunatic. The theodolite was knocked over, and the observer, struggling fiercely, found himself being rolled slowly nearer and nearer to the edge of a sheer precipice, not by a treacherous Pathan, as he had at first thought, but by his best friend. Fortunately one of his Indian *khalassis* was near enough to intervene and prevent a tragedy, and the fit of " mountain madness " passed, leaving the recorder quite unconscious that he had narrowly escaped Broadmoor or the gallows. The sequel is tragic. Within a year or two the observer was shot dead by one of his men while plane-tabling, and a few years later the recorder gave his life at Festubert in the Great War.

Woe betide the luckless surveyor who rouses the wrath of the wild elephant of the Himalayan jungles! " In the dense forests of Sikkim and Bhutan," writes a survey officer, " most well-graded footpaths are elephant paths. The elephant feeds along a contour-line, and seems to take a peculiar pleasure in uprooting survey-pegs fixed in his path. Once, for a whole week, I was haunted by these animals. On the first day, while plane-tabling with one of my men on a plateau with steep sides, I heard a loud trumpeting followed by a crashing of saplings which meant that an elephant was charging. Pitching the plane-table and tripod into a bamboo clump, we each made for a tree, but finding that I could not climb anything big enough with my boots on I rushed to the precipitous edge of the plateau and slid as far as I dared down a thick creeper. There I hung for some time whilst the ground above me shook from the angry stamping of a disappointed elephant. At last the brute moved off, and I was hauled up by some of my men to find my plane-table smashed, my measuring chains torn into short lengths, my flags broken to matchwood, and my notebook gone. Day by day we had our surprises. One day, while I was absent, a herd visited my camp. When I returned, my tents, furniture, instruments and utensils had vanished. We found some of the instruments in the jungle, and the tents in an elephant hollow where they had been well trampled into the mud. At the end of the week I reached a planter's bungalow, thinking that my troubles were ended. Vain hope! I was met by a man who told me that elephants had tumbled twelve out of twenty forest boundary pillars into the nearest streams."

Several Royal Engineers were surveying in Burma after the first stage of the Third Burma War, and among them Lieutenant (now Colonel) H. M. Jackson who worked as an assistant to Major J. Hobday of the Bengal Army. " Little could then be done without an escort," he says,[1] " as the country was overrun by Thibaw's

[1] Notes by Colonel H. M. Jackson, late R.E., sent to the author on September 8th, 1933.

disbanded soldiery. The first opportunity for any serious work was in the Southern Shan States Expedition in 1886–87. The existing map of these territories was more decorative than useful, but our surveying could only be of an entirely reconnaissance type. In the cold weather of 1888–89 I accompanied a small force despatched to suppress the Red Karens, whose country lies south of the Shan States. About this time the French were pushing up the Mekong which runs roughly parallel to the Salween, a river traversing the Shan States, and it appeared desirable to define a boundary on this side. I was attached to the Anglo-Siamese Boundary Commission, and succeeded in finding and marking the eastern watershed of the Salween which was the selected line. Captain T. F. B. Renny-Tailyour, R.E., was working in other areas of the Shan States during part of this period, and Captain C. F. Close, R.E., afterwards carried a precise chain of triangulation along the edge of the Shan Plateau."

Colonel Sir Charles Close,[1] K.B.E., C.B., C.M.G., F.R.S., the eminent geographer to whom Jackson alludes, served only from 1890 to 1893 in the Survey of India, but his remarks on the work in Burma are worth quoting :[2] "During my short stay I learnt something of the spirit of the Survey, and of the admirable work which it was doing for the Indian Empire. I was particularly impressed by the fact that the Survey officer did his own work and did not attempt to delegate it to subordinates. He gathered his experience in the field. At first I was put in charge of the Topographical Survey of Upper Burma, south of Mandalay. Everything was unfamiliar—the country and people ; the names of the different groups of the party ; the organization, and even the methods, of surveying. Who were the *barkhandarzes ?* Who were the *khalassis ?* Who was the *duffadar ?* Who, the *jamadar ?* What were the functions of the "writer" ? How were escorts obtained ? And a hundred other questions. During the next year I was in charge of a triangulation party, and had to spend many hours on hilltops observing angles at night to lamps at other stations situated usually some 30 miles distant. Those who travelled about the country in those days will always remember the little bamboo villages ; the *zayats* or rest-houses ; the *hpoongyi chaungs* or monasteries ; the yellow-clad monks ; the children gathering in the *chaungs* at sunset, repeating the praises of Buddha ; the general friendliness of the people ; and the tinkle of the bells, swayed by the breeze, high up around the tops of the pagodas."

[1] Colonel Sir Charles F. Close, one of several brothers in the Royal Engineers, entered the Corps in 1884. He was in charge of the Niger–Kamerun Boundary Survey in 1895, and in 1898 was British Commissioner on the Nyasa–Tanganyika Boundary Commission. From 1905 to 1911 he was head of the Geographical Section at the War Office, and from 1911 to 1922, when he retired, he was Director-General, Ordnance Survey. He was President of the Royal Geographical Society from 1927 to 1930.

[2] Notes by Colonel Sir Charles Close sent to the author on September 21st, 1933.

In 1888–89, a small survey party under Lieutenant W. H. Pollen, R.E., a popular officer who had been an Aide-de-Camp to the Marquis of Ripon, Viceroy of India, accompanied the military expedition to the Lushai Hills.[1] Unfortunately, Pollen died at Chittagong in March, 1888, from the malaria which he had contracted in the Lushai jungles. In the following winter, two columns set out, one from Burma into the Chin Hills, lying east of the Lushai Hills, and the other from Chittagong into the Lushai Hills. Each was accompanied by a survey party, that from Burma being under Lieutenant T. F. B. Renny-Tailyour, R.E., and the other under Lieutenant (afterwards Colonel) W. J. Bythell, R.E.[2] The operations in the Lushai Hills resulted in the survey of about 6,000 square miles of jungle, and those in the Chin Hills of one half that amount; but the interest of surveyors will centre chiefly on the Chin Hills party because its leader, now Colonel T. F. B. Renny-Tailyour, C.B., C.S.I., then laid the foundations of a career which emulated, on the Burmese frontiers, the careers of Gore and Wauhope in Afghanistan. Renny-Tailyour was present at the taking of Mandalay in 1885. He served in the Chin-Lushai Expedition in 1889–90, and on the expeditions in Upper Burma, in 1890–91, along the Chinese frontier. He was the Survey Officer with the Burma-China Boundary Commission in 1897, and again in 1898 and 1899.[3] No other surveyor has yet made such an important contribution to the maps of Upper Burma.

Among the survey officers in Burma towards the close of the last century was Lieutenant J. M. Burn, R.E., who observed with Captain C. F. Close, R.E., on the Great Triangulation from Rangoon to Mandalay, and later with Lieutenant (afterwards Colonel) H. H. Turner, R.E.,[4] from Mandalay to Bengal. Colonel H. A. D. Fraser, C.B., late R.E., who joined Burn as a subaltern in 1894 in triangulating through Upper Burma, describes a curious incident in camp:[5] "In a very wild part of the country I was awakened on my first night by a tickling sensation and disturbed a rat which was gnawing my moustache. Jumping up, I found that my tent was leaning over at a precarious angle, and subsequent investigation showed that rats had gnawed through every cotton rope except one or two. They gave the camp a very lively time for the next week. However, when some Kuki Naga coolies arrived, they caught the rats by dozens in

[1] The Lushai Hills lie N.E. of Chittagong between Assam and Burma. (See Map IV.)

[2] See Vol. I, Chapter XXII, p. 461.

[3] Colonel Renny-Tailyour's subsequent services in the Surveyor-General's Office at Calcutta have been mentioned in Chapter XII, pp. 225, 226.

[4] Colonel H. H. Turner, late R.E., joined the Corps in 1889 and the Survey of India in 1897. He extended the Great Triangulation from the Indus to Kalat and through Baluchistan. He served with the Mekran Expedition in 1898, in S. Africa in 1902–03, in Mesopotamia in 1915–16, and later in the Headquarter Offices in Calcutta. He died in 1930.

[5] Notes by Colonel H. A. D. Fraser, C.B., late R.E., sent to the author on November 16th, 1933.

snares, impaled them on split bamboos, and toasted and ate them as a great delicacy."

Incidentally, Fraser tells an amusing tale of Colonel John Hill, late R.E., a survey officer under whom he worked as a youngster. Hill preferred the free life of a field party to the tedium of an administrative post in Calcutta, and he possessed a keen sense of humour. It seems that on one occasion, through an oversight, his camp office failed to report at once the death of a sub-overseer, and in consequence he received an official reproof which concluded with the remark: "You should therefore immediately report the death of all your subordinates." Setting a laudable example of prompt and implicit obedience, he replied, "*Sir, I have the honour to report the death of all my subordinates.*" History does not record the result.

Many are the troubles of a topographical surveyor in the outlying parts of Burma. The triangulator's intersected points are mostly hilltops, and the difficulty lies in the practical impossibility of finding these on the ground.[1] From the theodolite station they are readily identifiable; but from the floor of the jungle the situation is very different. The surveyor, shut in on all sides and cutting his way through the undergrowth, cannot know whether the low hill he has just climbed is the one he saw from the theodolite station some miles away. After the rains, river-crossings with mules are often difficult, and a certain number of these animals are lost each year from exhaustion through getting bogged in quicksands or swamps. As a Bengali surveyor put it when explaining such a loss, "Sir, three times that mule fell down in the quicksand, and the third time he could not sustain." Early-morning fogs persist with the beginning of March. Then follows a brief period of warm clear days, but very soon the smoke and heat-haze set in which herald the approach of the hot weather. By the end of March, the air is so thick with smoke from jungle fires that triangulation becomes impossible and plane-tablers have difficulty in seeing their points. The thunder-showers of April and early May bring in the first malaria, and all surveying ceases in May."

But the life has its attractions. If opportunities for big-game shooting are disappointing, this is compensated by the excellence of the small-game shooting. An hour or two before sunset, the hills along the skyline, lightly veiled with the faintest blue haze, blend with the deeper blue of the sky. The sun sets at last in a blaze of gold and pink, succeeded by a deep orange glow over the western horizon. A silence falls which is broken only by the occasional call of a barking deer in the surrounding jungle. Then, against the last glow of the sunset, the flighting duck flash overhead with the swish of many wings. The sportsman's opportunity has come.

[1] "A Survey Party in Upper Burma," by Captain G. F. Heaney, R.E., appearing in *The R.E. Journal*, Vol. XLVII, January–June, 1933, pp. 282–289.

Interesting experiences in Burma fell to the lot of Colonel E. T. Rich, C.I.E., late R.E., an able surveyor whose exploits on the North-West Frontier will be described later. "I was transferred to Burma in 1911," he writes,[1] "and was posted to a survey party on the frontier at Myitkyina on the Irrawaddy. Beyond us, to the north, was tribal territory which we were forbidden to cross; whilst to the east, up to the Chinese border 40 miles away, the country was partially administered. I remained in charge of this party for 13 years, except during the Great War, and left it on promotion in 1924. By 1926, practically the whole of the territory reaching to Tibet in the north, and to the Chinese frontier in the north-east, had been brought under semi-administrative Government control; and all this area had been surveyed, as well as large unadministered areas to the west of Myitkyina in the Hukawng Valley and the Naga Hills. In the latter regions, where my party surveyed from 1920 to 1924, the people still kept slaves, and the Nagas were head-hunters and practised human sacrifices. Very few white men had ever crossed this country. Soon after the commencement of the survey, trouble began to arise over the slaves who constantly ran away from their masters and took refuge with us. On one occasion, four Kachin slaves, who owned property and had large families, escaped to Burma, leaving their families behind. They then wished to free their wives, children and other relatives in exchange for their property and some money, and I was asked to arrange the matter. After much argument the masters agreed to sell the families if the prices were satisfactory, so I held a regular valuation. An able-bodied male slave was to be freed in exchange for a buffalo, a spear, two baskets of rice and ten rupees, and so on down to small children who went for two to six rupees each. At the end of several hours, however, all the money and goods were exhausted, and there still remained an elderly and decrepit dame whom her owner was finally persuaded to throw in for nothing. Whereupon the old lady abused, not only her late owner, and her relations, but me also for putting her down as of no value!"

The names of Colonels M. S. Bell, V.C., C.B., and C. H. D. Ryder C.B., C.I.E., D.S.O., both of the Royal Engineers, are connected inseparably with the exploration of the vast territories of China and Central Asia. Bell gained the Victoria Cross at Ordasu during the Ashanti Expedition of 1873–74, having fought already in Bhutan and in Hazara on the North-West Frontier, and he was on active service again in the Third Burma War. In 1886, after the campaign in Burma, he made a remarkable journey of 3,500 miles from Peking to Kashgar, north of Kashmir. He set out from the Chinese capital with Lieutenant (afterwards Major-General Sir

[1] Notes by Colonel E. T. Rich sent to the author on November 15th, 1933.

Francis) Younghusband, of the Indian Army,[1] and the latter marched to Kashmir and India by the Alashan route through Barkal and Kashgar. Bell himself went by way of Si-Nyan-Fu, and the provinces of Shensi and Kansu, to Hami, Karashahr and Kashgar, and was thus the first to traverse what is known as the Great Central Asian trade-route. These, and other explorations, were described by him in a number of volumes. Of Bell, Lord Curzon remarked: "His extraordinary travels over almost the whole Asian continent, though little known to the public, entitle him to be considered the territorial Ulysses of this age."[2]

Captain C. H. D. Ryder, R.E., first came into prominence as an explorer at the end of 1898 when he was attached to an expedition under Major (afterwards Major-General) H. R. Davies, Oxfordshire Light Infantry, to explore, map and report on the Province of Yunnan in South-West China.[3] Joined by Lieutenant W. A. Watts-Jones, R.E., he travelled through China for seven months and then returned to England. In November, 1899, however, he started on another trip with Davies from Bhamo in Upper Burma. Entering the Yunnan Province, he completed its survey and then extended his journey into Sechuan and Chinese Tibet to the north. Finally he reached Shanghai, down the Yangtsekiang, in July, 1900, during the Third China War, and took part in that campaign. His journeys took him over some of the ground traversed later by that remarkable explorer, Sir Aurel Stein, K.C.I.E., an archæologist who, between 1888 and the present day, has penetrated repeatedly into the most inhospitable regions of Asia, and whose numerous publications, such as *The Ruins of Desert Cathay* and *Innermost Asia*, are highly esteemed in geographical and archæological circles.[4]

Ryder had not long to wait before another opportunity occurred for exploration. On this occasion his work lay in Tibet. Prior to 1903 the Survey of India had been unable to operate in that country because the Government at Lhasa had never allowed British surveyors to enter it. In 1903, however, because of the truculence of the Tibetans and their overtures to Russia, a Mission was sent to Lhasa under Colonel (afterwards Sir Francis) Younghusband, with

[1] Younghusband became Political Agent at Chitral in 1893, and afterwards served as such elsewhere on the North-West Frontier. He was a noted explorer of the Pamirs and Karakorums, and was head of the Tibet Mission in 1903–04 (see Vol. I, Chapter XXII, p. 462 *et seq.*).

[2] A memoir of Colonel M. S. Bell, V.C., C.B., late R.E., appears in *The Geographical Journal*, Vol. XXVIII, July–December, 1906, p. 187.

[3] "Exploration in Western China," by Captain C. H. D. Ryder, R.E., appearing in *The Geographical Journal*, Vol. XXI, January–June, 1903, pp. 109–126.

[4] Dr. M. Aurel Stein began his archæological and exploratory career with antiquarian researches in Kashmir and on the Afghan border in 1888–89. He carried out archæological explorations for the Indian Government in Chinese Turkestan in 1900–01, and archæological and geographical explorations in Central Asia and Western China in 1906–08. He joined the Archæological Survey, from the Education Department, in 1910, and explored in Central Asia and Persia from 1913 to 1916. He worked in Upper Swat, Baluchistan and Mekran in 1926–28, and in Persian Baluchistan in 1932.

Major (temporary Brig.-General) J. R. L. Macdonald, R.E., in command of the escorting troops,[1] and this afforded an excellent opportunity of extending our maps across the Himalayas into Tibet. Colonel St. G. C. Gore, late R.E., the Surveyor-General at that time, was experienced in the art of surveying with armies in Afghanistan, and he realized that, for the Tibet Mission, an officer of initiative and quick decision was needed who could take advantage of fleeting opportunities for rapid work, and yet was an expert also in deliberate methods. His choice fell on Ryder, to whom he allotted Lieutenant H. McC. Cowie, R.E., as an assistant. During the military advance, these two were able to map the Tibetan Plateau from Sikkim to Lhasa, and Ryder succeeded also in fixing the positions and heights of the peaks of the Nyen Chen Tang La Range, the greatest of which towers to 23,555 feet.

When the Mission had completed its work in Lhasa and was returning through Sikkim to India, Ryder asked for permission to survey the whole length of the Tsan-po Valley to its sources and also the Manasarowar Lakes in that area. This was approved, and Captain C. G. Rawling, Somersetshire Light Infantry, and Lieutenant F. M. Bailey, 32nd Pioneers, were selected to accompany him as Political Officers, Bailey being one of the few officers who knew the Tibetan language. As Cowie's health had suffered, he returned to India, and Captain (now Colonel) H. Wood, R.E., who had surveyed in Nepal,[2] was appointed in his place. With a few Indian surveyors and *khalassis*, an escort of only five Gurkha soldiers, half a dozen servants, and a spaniel, Ryder, Rawling, Bailey and Wood plunged into the unknown on what was called the "Gartok Expedition."[3]

The surveys of Ryder and Wood were necessarily a race against time, for unless they could reach Simla, *via* the Sutlej, by the beginning of January, they might be snowbound in Tibet for the winter and spring. They started from Gyantse on October 9th, 1904, and on January 11th, 1905, travel-stained but in good fettle, they marched into Simla. In less than three months they had plane-tabled an area of 40,000 square miles, surveying the Tsan-po from Shigatse to its source and also the Manasarowar lake region. In addition they had surveyed the Sutlej from its source near that of the Tsan-po to its entry into British territory, and also the Gartok branch of the Indus. At times the cold was very severe, 56 degrees of frost being

[1] The military operations during the Tibet Expedition of 1903–04 are described in Vol. I, Chapter XXII, pp. 462–470.

[2] Wood had been sent to Nepal in 1903 chiefly to investigate the supposed identity of a peak visible from Katmandu with Mount Everest. This was Gaurisankar. Wood's knowledge of Nepal was useful to Ryder.

[3] See *The Great Plateau, Part II, The Gartok Expedition*, 1904–05, by Captain C. G. Rawling. By the treaty signed at Lhasa, the Tibetans undertook to open trade-marts at Gyantse, Yatung and Gartok. The first two places were well known, but more information was required about Gartok and its approaches. Gartok lies in Tibet about 100 miles east of the Kashmir border.

recorded on one occasion. When the air was still, the cold was quite endurable; but when the wind blew, which was generally the case, no clothing was sufficient to keep them warm. The surveyors worked at heights almost always exceeding 13,000 feet; and near Shigatse, Wood observed from a peak whose summit was over 18,500 feet above sea-level. "To climb one of these hills," says Ryder,[1] "is itself a hard piece of work: to observe at the top in a bitter wind is one of the most physically-painful operations I have ever experienced. To do this, in combination with a march, is a very long and hard day's work. Captain Wood carried this on for days and months with hardly any intermission—a feat which could only have been accomplished by an officer of his energy and determination." Excellent maps of Southern Tibet resulted from the Gartok Expedition, and the heights of many newly-discovered peaks were fixed on both sides of the Tsan-po. For his work in Tibet, Ryder was awarded a gold medal by the Royal Geographical Society.

In October, 1911, a military force was concentrated above Dibrugarh on the Upper Brahmaputra to subdue the Abors and, if possible, to define a boundary between Assam and Tibet, and a survey party under the command of Captain (now Colonel) O. H. B. Trenchard, R.E., was attached to it.[2] Trenchard was assisted by Lieutenant G. F. T. Oakes, R.E., and was joined later by Lieutenant J. A. Field, R.E. Very little surveying could be done until hostilities ceased in the middle of December, but exploration parties afterwards laboured until the end of March, 1912, in the densely-wooded and mountainous areas of the northern portions of the Dihang Basin. In the autumn, with Lieutenant P. G. Huddleston, R.E., in place of Field, the survey parties returned to the Abor country and worked steadily until the middle of August, 1913. Almost the entire area of the Dihang Basin up to the borders of Tibet and Pomed was then surveyed on a scale of ¼-inch to a mile, and the identity of the Tsan-po with the Dihang was practically established, although Trenchard was unable to explore one length of about 30 miles of the river. Huddleston seems to have displayed great energy in a number of small explorations. Unhappily he, Oakes and Field were killed, or died, during the Great War.

A peaceful Mission was despatched, in the autumn of 1912, to the country of the Mishmis, east of the Abor territory and lying around the Dibang and Lohit tributaries which join the Dihang near Sadiya

[1] "Exploration and Survey with the Tibet Frontier Commission, and from Gyangtse to Simla *via* Gartok," by Major C. H. D. Ryder, D.S.O., R.E., appearing in *The Geographical Journal*, Vol. XXVI, July–December, 1905, pp. 369–391.

[2] A full account of the Abor Survey operations is given in a report entitled "The Abor Expedition Survey Detachment, 1911–12, and the Abor Exploration Survey Detachment, 1912–13," by Captain O. H. B. Trenchard, R.E., reproduced from the *Records of the Survey of India*, Vol. IV, 1914, in *The R.E. Journal*, Vol. XXI, January–June, 1915, pp. 221–241 and 268–292.

to form the Brahmaputra.[1] The survey party which accompanied this Mission was under the leadership of Captain C. P. Gunter, R.E.,[2] assisted by Lieutenant H. T. Morshead, R.E., a remarkable mountaineer who figures later in this narrative. Most of the work lay along the course of the Dibang running northwards from Sadiya, and it was arranged that Gunter should carry out the topographical survey and Morshead the triangulation. The difficulties were almost insuperable; yet they were overcome. Morshead was a wonderful triangulator, and Gunter an excellent topographer. The main ranges of Mishmiland, varying as they do from 15,000 to 17,000 feet in height, drop in a distance of four or five miles to the level of the valley which is about 4,000 feet.[3] The slopes of the gorge through which the Lohit cuts its way are often nearly 40 degrees, and the general fall is over 40 feet in a mile. The river is practically a torrent for 90 miles. The mountain tops are a series of rock-pillars, sometimes 200 to 300 feet high, joined together by snow-covered ridges. Mists and clouds prevail even on the finest days. However, between November, 1912, and May, 1913, Gunter and Morshead traced the Dibang to its sources, surveyed most of its basin, and reconnoitred other parts of the Mishmi country.

While exploring far up the Dibang, the surveyors met some Tibetans from the province of Kham who offered to guide them into Tibet; and, as this seemed an opportunity to establish the identity of the Tsan-po with the Brahmaputra, Morshead was allowed to set out northwards on May 16th, 1913, in company with Captain F. M. Bailey of the 32nd Pioneers, the officer who had marched with Ryder in Tibet in 1904. Towards the end of June, after crossing two high passes, the explorers reached a place called Showa, on the Upper Dihang and were there kept prisoners for three days because they were believed to represent a southern flank attack by the Chinese, who had been expelled from Tibet only 18 months before;[4] and when this illusion was dispelled, the suspicions of the Tibetans were roused once more at the sight of the Chinese characters on a tablet of Indian ink which Morshead was using. Writing to the author in 1930, Morshead remarked that the incident seemed amusing enough in retrospect, but that actually the lives of the party were at stake. He described a visit which he and Bailey paid to the Tibetan

[1] See Map IV, "Sketch Map of the North-East Frontier," at the end of this volume. An outline of the operations in the Abor and Mishmi countries is given in Vol. I, Chapter XXII, pp. 470–474.

[2] Colonel C. P. Gunter, C.I.E., O.B.E., served chiefly in the wilder parts of India and Burma. He was Director of the Frontier Circle of the Survey of India in 1926, and retired in 1928. During the Great War he was in charge of the G.H.Q. Mapping Section in Mesopotamia in 1916–18. His paintings of scenes in India, Burma and Mesopotamia have been much admired.

[3] "The Mishmi Survey Detachment," by Captain C. P. Gunter, R.E., appearing in *The R.E. Journal*, Vol. XXI, January–June, 1915, p. 2.

[4] A full account of this exploration is given in an article entitled "An Exploration in South-East Tibet," by Major H. T. Morshead, D.S.O., R.E., appearing in *The R.E. Journal*, Vol. XXXIII, January–June, 1921, pp. 21–40.

Dzongpen, or head official. After the customary enquiries about the visitors' health and the hardships of their journey, the next question was regarding their ages. In Tibet the calendar is reckoned by a 12-year cycle, each year being given the name of one of 12 animals. Thus a " horse-year man " must have been born in such a year as 1882, 1894 or 1906, and the enquirer is left to guess, from his visitor's appearance, the particular cycle of his birth. When Morshead replied that he was a " horse-year man," the *Dzongpen* raised his eyebrows in feigned polite astonishment and murmured, " Really, your dignity is such that I should have thought you were at least *twice* that age." Showa is the capital of the province of Pomed (or Pomé). As the inhabitants were then reputed to kill all travellers who were worth looting, Morshead and Bailey were very fortunate to escape harm.

It is impossible to follow, step by step, the journey accomplished by these two young officers beyond stating that from Showa they made a circuit north-westwards, westwards and then southwards, through Tangme and Trulung, until they struck the Tsan-po at Pe. Then they tried to follow the river down to India, but could get little farther than a spot called Pemako-Chung below Gyala Sindong. There the roaring torrent of the Tsan-po was found to enter a stupendous chasm, on either side of which the mountains towered to heights of over 23,000 feet. No man could pass by such a road. They retraced their steps to Pe, where they heard that Captains O. H. B. Trenchard and S. Pemberton, R.E., had arrived a few days earlier but had soon returned towards Assam. Morshead and Bailey next journeyed up the Tsan-po to Tsetang, not far from Lhasa, and after extensive explorations towards the south, returned to India through Bhutan in the middle of November, 1913, having covered 1,680 miles through country which was almost unknown. The excellent route-surveys executed by Morshead added greatly to the existing geographical knowledge of Eastern Tibet.[1]

Two years before this adventure with Morshead, Captain F. M. Bailey had made a remarkable journey from China to Assam, one of his aims being to solve the problem of the mythical falls of the Tsan-po. He left Peking in March, 1911, and was at Yen-Ching on the Mekong before the middle of June. Crossing the watershed between the Mekong and the Salween, he came to Rima on the China-Mishmi border, and then followed the course of the Lohit until he

[1] It may be of interest to record that when Morshead was observing in the Mishmi Hills, he intersected a new and very high snow peak, and this peak was intersected also by Oakes and Field with the Abor Expedition. Subsequently, when in Tibet with Bailey, Morshead reached the base of this mountain and found that its name was Namcha Barwa (25,145 feet). As Morshead afterwards pointed out, this peak lay at the point where the Tsan-po turns to break through the Himalayas, and where the existence of a high peak had been foreseen, as very probable, by Sir Sidney Burrard (*Sketch of Himalayan Geography*, by Burrard and Hayden, 1907). The prediction was based upon the analogies of other great Himalayan rivers, such as the Indus, Sutlej and Yurungkash in the Kun Lun.

marched into Sadiya on August 7th.[1] He was never near the Tsan-po, but he made careful survey observations of his route during his journey of 1,715 miles from the Yangtsekiang.[2] At about this time, Captain (now Colonel) M. N. MacLeod, R.E., was working under Lieut.-Colonel H. L. Crosthwait, R.E., in the Survey Drawing Office at Simla, busily preparing a map of Persia from the reports and sketches of many explorers and travellers, an operation which he describes as analogous to solving a jig-saw puzzle; for instance, one sketch showed some ground as "salt swamp," while the next showed it as "stupendous mountain"! "One day, after Crosthwait had gone on leave," writes MacLeod,[3] "a stranger walked into my office and asked if I could help him. He announced himself as Captain Bailey, and added that he had just arrived from Peking through Assam. He wished to prepare a map of his route from the observations which he had taken, but could find no one to tell him how to set about it. As it happened, his arrival was most opportune, for negotiations were actually in progress regarding the common frontiers of India, China and Tibet, and were greatly handicapped for want of proper geographical information about the regions which Bailey had traversed. I produced a map and asked him to indicate his line of march. This he did, and then left his notebooks with me until the next morning, by which time I had prepared a map reasonably consistent with what little previous information was available about the country. I was able later to elaborate the rough traverse made from Bailey's notebooks from further information which he supplied, until eventually we had compiled a map of a substantial portion of the area concerned in the negotiations. This area was afterwards surveyed by the Survey of India, and Bailey's map emerged well from the comparison."

We return now to the north-west where Captain E. T. Rich, R.E., was engaged between 1905 and 1909 in surveying the frontier from the Kohat Pass northwards. During those four years, Rich and his party triangulated and surveyed many thousands of square miles in the Peshawar and Abbottabad districts; but their chief work lay in the unadministered tribal territory between Kohat and the Malakand, and in the Mohmand country, Dir, Swat and Buner. They worked throughout under war conditions, although the only military operations which took place were the Zakka Khel and Mohmand Expeditions in the spring of 1908. In 1905, no official

[1] These rivers and towns are shown on Map IV at the end of this volume.

[2] An account of this journey is given in an article entitled "Journey through a Portion of South-Eastern Tibet and the Mishmi Hills," by Captain F. M. Bailey, appearing in *The Geographical Journal*, Vol. XXXIX, January–June, 1912, pp. 334–346.

[3] Notes by Colonel M. N. MacLeod, D.S.O., M.C., late R.E. (now head of the Geographical Section of the War Office) sent to the author on October 18th, 1933. MacLeod entered the Survey of India in 1905, served on the N.W. Frontier in 1907–08 and later in various other parts of India. He reverted to the Home Establishment after serving in the Great War.

was allowed to leave the strongly picqueted main road through the Khaibar Pass, nor even to halt except in one of the forts ;[1] and for a Survey party to wander over the neighbouring country, and to camp for months among the tribal villages, was made possible only through the remarkable personality and influence of Colonel Roos Keppel and his assistant Abdul Qayum.[2] The forbidding hills and valleys of this territory are divided into well-defined areas of which every tribesman knows the boundaries, and woe betide the shepherd of one tribe who allows his flocks to graze on ground belonging to another. Rich had to make arrangements with many tribes and clans, most of whom had blood feuds against each other. Nothing would have been easier than for a tribesman to enter his enemies' land, murder a surveyor or two, and then fasten the blame on his adversaries. So Roos Keppel assembled all the tribes over a large area, and induced them to agree that, for a time, all blood feuds should cease, and that they should be jointly responsible for the safety of the surveyors. After that, not a shot was fired while the work was in progress, though many interesting situations arose. Men of antagonistic tribes became good friends and joined Rich in his climbs over the mountains ; yet they never failed to tell him that, on the day after the truce ended, they would do their best to kill each other. When he was introduced to the notables of any tribal community, and had shaken hands with the headmen and elders, the next personage to be presented was the *Ujrati Katil* or "hired assassin," an honoured member of the clan. No ill-feeling was shown against this man by those whose relatives he had killed, and he could only be killed himself if he were caught in the act. Fifteen years later, across the northern borders of Burma, Rich found the "hired assassin" flourishing under exactly the same conditions.

When Lenox-Conyngham began the second series of pendulum observations in India in 1903,[3] the International Geodetic Association at Potsdam pointed out that the Russian pendulum observations had yielded results out of harmony with those of Europe, and that international geodesy would benefit by an exact connection between the triangulations of India and Russia. As the connection made by Holdich and Wauhope in 1895 was not sufficiently precise for modern scientific deductions, it was decided in 1912 that a new chain of triangles should be carried across the Karakorum and Hindu Kush mountains of Hunza to join the triangulation of Kashmir to the Russian stations on the Pamirs. The Gilgit Series of Principal Triangulation, begun by Dr. J. De Graaff Hunter in 1909 and completed by Lieutenant H. G. Bell, R.E., in 1911, had carried the

[1] Notes by Colonel E. T. Rich, C.I.E., late R.E., sent to the author on November 15th, 1933.

[2] Afterwards respectively Sir George Roos Keppel, Chief Commissioner, N.W.F.P., and Sir Abdul Qayum, now Member for the N.W.F.P. on the Council of State.

[3] See Chapter XII, pp. 213, 214.

ON THE RUSSIAN STATION OF SAARBLOCK IN THE PAMIRS, 17,284 FEET.

Indian system from the neighbourhood of Rawalpindi to Gilgit, but the difficulty of extending it to the Afghan boundary was obviously very great. It was finally decided that the Hunza Valley route was the only feasible one, and the triangulation was entrusted to Bell and two assistants, who began their work in the summer of 1912.

Unhappily, Bell fell seriously ill, near the Pamir border, after he had reconnoitred in that direction and had met the Russians. On July 19th he awoke in great pain and was carried by his men to his base camp near the Mintaka Pass. Unable to work, and growing rapidly worse, he wrote at last to his nearest European assistant, asking the latter to come to the camp and take charge of the operations, but on the 25th he passed away. The lonely death of this young and capable surveyor was as great a blow to the Survey of India as that of Captain Basevi in Tibet in 1871. Lieutenant Kenneth Mason, R.E., was appointed to succeed Bell in 1913, and with two assistants, and accompanied by Lieutenant R. W. G. Hingston, I.M.S., as geologist and botanist, he extended the Hunza chain of triangulation from Bell's terminal stations. The link with the Russian triangulation was made at Saarblock in the Pamirs during the summer, but the outbreak of the Great War in 1914 prevented the Russian surveyors from filling a gap in their own triangulation near the Caspian Sea. "To those of us who were permitted to take a share in the work," writes Mason, "the memory of those days spent in the high camps of those vast open spaces, and the recollection of the gigantic scale to which Nature has built the mighty barrier wall of this Great Empire, will always bring back the fascinating times passed among the silent Lords of the Mist-Mountains."[1]

The exploration of the Karakorum, with its immense glaciers, was begun by Captain T. G. Montgomerie, B.E., and Captain Godwin-Austen in 1861–62, and continued by Sir Francis Younghusband, Sir Martin Conway, Dr. and Mrs. Workman, the Eckenstein-Guillarmod Expedition, the Duke of the Abruzzi and Dr. T. G. Longstaff; but a more elaborate scheme was undertaken in April, 1914, when an Italian expedition under Dr. Filippo de Filippi set out from India to explore this region and Eastern Turkestan.[2] Major (now Colonel) H. Wood, R.E., was deputed by the Surveyor-General to accompany and assist the Italians, and he proceeded to make a detailed survey of the Karakorum Pass over the Central Asian watershed and of the regions on both sides of the Pass. In the course of

[1] A full account of the work of this expedition appears in *Records of the Survey of India*, Vol. VI, "Completion of the Link connecting the Triangulations of India and Russia, 1913."

[2] The work of the Filippi Expedition is described in a Survey of India publication of 1922, entitled *Explorations in the Eastern Kara-Koram and the Upper Yarkand Valley*, 1914; and also in an article entitled "Expedition to the Karakoram and Central Asia," by Cav. Dr. Filippo de Filippi, appearing in *The Geographical Journal*, Vol. XLVI, July–December, 1915, pp. 85–105.

this work he made the interesting discovery that the Rimo glacier, which bifurcates during its descent from the Karakorum Range, sends one branch towards the Indus and the Arabian Sea and the other northwards into the Yarkand River and the lake basin of Central Asia. It was not until October 13th, 1914, that Wood marched into Yarkand, and there heard, for the first time, that England was involved in a European war.

The outbreak of hostilities took the Survey of India by surprise. Lieut.-Colonel C. H. D. Ryder, D.S.O., R.E., had been assisting, since December, 1913, in the demarcation of a Turco–Persian boundary, 1,180 miles in length, from the Persian Gulf northwards to Mount Ararat. He did not finish this task until October, 1914, when he said good-bye to his Turkish and Persian colleagues only 24 hours before Turkey declared war. Ryder pays a tribute to the skill and energy of Major H. McC. Cowie, R.E., who carried a system of triangulation northwards until it joined that of the Russians near Urmia, and to Captain (now Sir Arnold) Wilson who was the British Commissioner during the latter part of the operations.[1] He also relates some amusing incidents. For instance, an Arab sheikh, visited by a portly foreign representative, gravely remarked, "This morning my village was honoured by a visit from the Father of Bellies." Two Kurdish villages were entered whose names were found to mean "Breaker of Nails" and "Tearer of Pants." Such surprises served, no doubt, to enliven the monotony of hard work and harder travelling. They raised a laugh before laughter was drowned in the blood and misery of war.

Many Royal Engineers have climbed in the Himalayas, but none to such altitudes as those attained by the late Lieut.-Colonel H. T. Morshead, D.S.O., who, alas, was murdered at Maymyo in Burma in May, 1931.[2] After surveying in Mishmiland, exploring in Tibet, and fighting in the Great War, Morshead began his mountaineering career by joining Dr. A. M. Kellas in 1920 in an attempt on Mount Kamet, a peak in the Garhwal District which rises to a height of 25,445 feet. The party reached an altitude of 23,500 feet without the use of oxygen, but failed to gain the summit, chiefly because the attempt was made too late in the season. Many of the porters succumbed to mountain sickness, and the arrangements for cooking were unsuitable. The lessons of this failure were not wasted on Morshead: they spurred him to greater feats of endurance. Yet he climbed always as a surveyor. His primary object in gaining a summit was to fix its position and to map the surrounding country. It is characteristic of the modesty of the Survey of India that its officers and men have climbed many difficult peaks, above 18,000 feet in height, without the

[1] "The Demarcation of the Turco-Persian Boundary in 1913–14," by Colonel C. H. D. Ryder, appearing in *The Geographical Journal*, Vol. LXVI, July–December, 1925, pp. 227–242.

[2] A memoir of Lieut.-Colonel H. T. Morshead, D.S.O., R.E., appears in *The R.E. Journal*, Vol. XLV, July–December, 1931, pp. 719–723.

publication of any account beyond a statement of the angles and heights observed. Professional mountaineers are usually equipped with all modern appliances for climbing, and are not encumbered by survey instruments. The surveyor, on the other hand, climbs without any special equipment and has often to carry a theodolite or a plane-table. Climbing is not his hobby, but his daily work. Occasionally he joins in some great adventure such as an assault on Mount Everest. Then, and then only, does he come before the public eye. Morshead was such a one. He took little with him on his expeditions. His surveying instruments came before his personal belongings: his profession before his comfort.

In 1921, Morshead accompanied the first (reconnaissance) expedition to Mount Everest under Lieut.-Colonel C. K. Howard-Bury, and was assisted in his work by Brevet-Major E. O. Wheeler, M.C., R.E. They surveyed about 12,000 square miles of new country and Morshead climbed to a height of 22,000 feet.[1] In the following year he accompanied the second Everest Expedition, under Brig.-General the Hon. C. G. Bruce, when Captains G. I. Finch and J. G. Bruce ascended to over 27,000 feet. Morshead failed above the North Col,[2] at a height of about 25,000 feet, through exhaustion and frostbite. Relating his experiences to the author, he said that he attributed this sudden onset of exhaustion to thirst. He needed more liquid than the average man, and could not get sufficient by melting snow with a small spirit lamp. When he had been assisted down from the North Col, and had drunk from a glacier stream, his exhaustion vanished. He suffered agony, however, from his frostbitten right hand. It was dressed by a medical member of the party who recommended amputation of several fingers; but Morshead preferred to risk blood-poisoning in trying to save some of the fingers.

Writing in 1922 on the subject of this attempt on Mount Everest, General Bruce says:[3] "As a *tour de force* it stands, in my opinion, by itself. It was the most terrific exertion, carried out during unfavourable weather and in the face of a dreadful west wind. It was a tremendous effort unparalleled in the history of mountain exploration." Morshead's injury prevented him from taking part in the Everest Expedition of 1924 under Bruce; and when the party under Mr. Hugh Ruttledge attempted the ascent in 1933 and

[1] "Report on the Operations of the Mount Everest Survey Detachment," by Major H. T. Morshead, D.S.O., R.E., appearing in the *Records of the Survey of India*, Vol. XVI (1921–22), pp. 109–120. Much information about the high peaks and principal mountain ranges of Asia is given in *A Sketch of the Geography and Geology of the Himalaya Mountains and Tibet* (1907), by Colonel S. G. Burrard, R.E., F.R.S., and H. H. Hayden, B.A., F.G.S.

[2] The photograph of Mount Everest in 1922, which appears opposite page 220, does not show the North Col. The Col lies below the left-hand end of the seemingly almost horizontal ridge which extends from the summit, and is hidden by the nearer *massif*. Recent attackers of Everest have followed a route just below this ridge.

[3] *The Assault on Mount Everest*, 1922, by Brig.-General the Hon. C. G. Bruce, C.B., M.V.O.

Lord Clydesdale flew twice over the summit during April of that year, Morshead was in his grave. But his inability to climb in 1924 did not prevent him from accompanying a party in 1927 which made the first crossing of Edge Island in Spitsbergen. By his death, the Survey of India lost a born mountaineer and explorer, and a most lovable character.

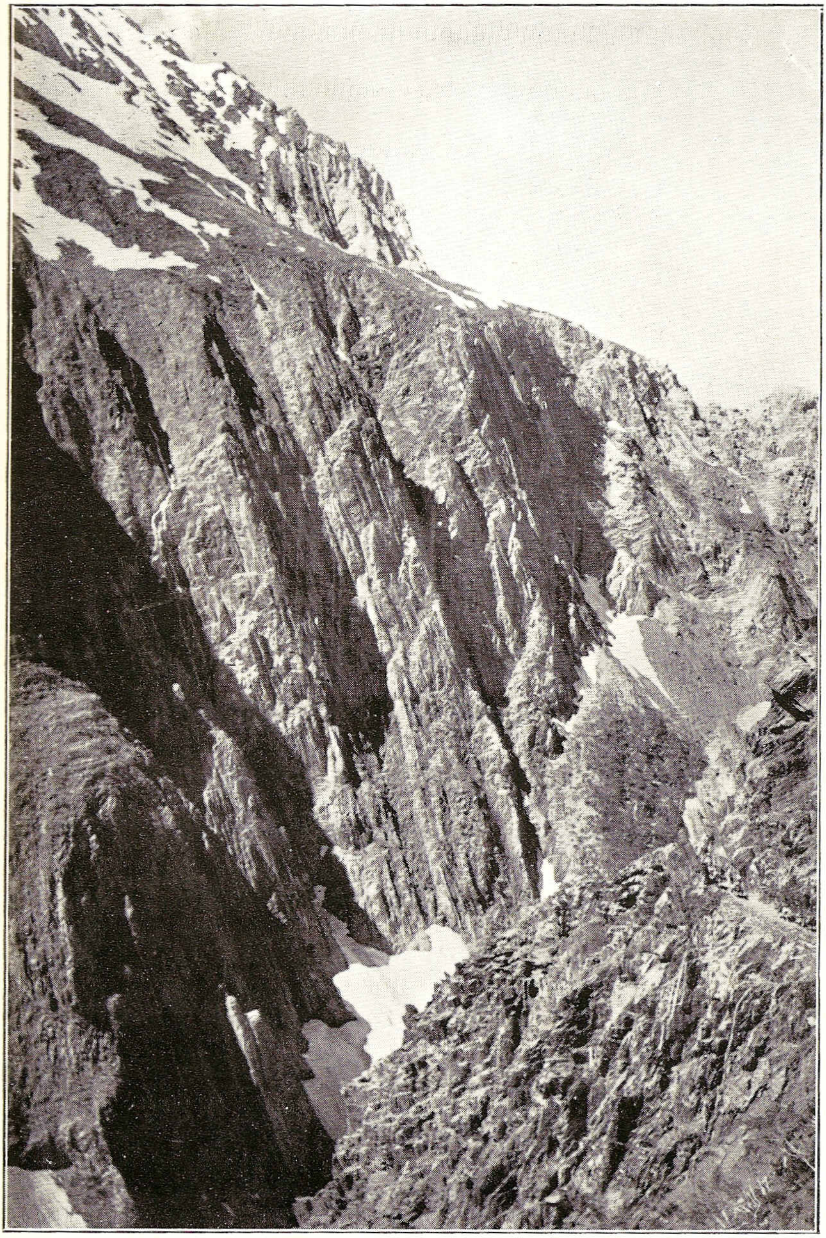
A valuable exploration was carried out in 1926 by Major Kenneth Mason, M.C., R.E.,[1] for which he was awarded a Founder's Gold Medal by the Royal Geographical Society. He supplemented Wood's survey of the Karakorum Pass by surveying the glaciers of the Shaksgam Valley which drain the northern slopes of the Karakorum range, north-west of the Pass, and he succeeded in filling, by accurate work, much of the gap between the surveys of previous explorers. Mason was accompanied by Major H. D. Minchinton, M.C., 1st Gurkhas, Captain F. O. Cave, M.C., Rifle Brigade, and Major R. C. Clifford, D.S.O., M.C., I.M.S. The party set out from Srinagar in Kashmir on May 9th and, a few days later, traversed safely the Zoji-La on the trade route into Ladakh and Central Asia. "On a cloudless night in spring, after two fine days, it offers an absolutely safe passage," says Mason.[2] "Under any other conditions of time or weather, it is dangerous at this time of year. But there are still some people in the world who regard an avalanche as an act of God." The adventures of Mason's party, their difficulties with coolies and ponies, and the hardships which they experienced on the windswept roof of the world, cannot be recorded here. Excellent maps and photographs resulted from their labours, and much information of scientific value. With the approach of winter they left the desolate highlands, and arrived in Srinagar early in November.

This sketch of the history of the Survey of India may end with a mention of a survey of the complex mountain area forming the Valley of Chitral, the Swat Valley and the Indus Kohistan, executed between 1927 and 1931 under the direction of Lieut.-Colonel C. G. Lewis, O.B.E., R.E. It included the gigantic Hindu Kush range which here constitutes the boundary between India and Afghanistan and is capped by glaciers having an aggregate length of more than 1,500 miles. This survey, on a scale of 1 inch to the mile, is the largest ever undertaken of so high and glaciated a region, and its successful completion reflected great credit on Lewis and his assistants.

Who can say what lies before the Survey of India? Money is scarce: staffs are depleted. But all who read the history of this department must admit that it has glorious traditions, and that its wide activities have brought great benefit, not only to India, but to the whole world.

[1] Now Lieut.-Colonel K. Mason, M.C., R.E. (retired), Professor of Geography, University of Oxford.

[2] "Exploration of the Shaksgam Valley and Aghil Ranges," by Major Kenneth Mason, M.C., R.E., forming Vol. XXII of *Records of the Survey of India*, p. 11.



THE GORGE OF THE ZOJI-LA, KASHMIR.

From time immemorial the main trade route between India and Central Asia has crossed this pass.

CHAPTER XIV.

ARCHÆOLOGY AND GEOLOGY.

> " Thrice blest the man who with himself can hold
> Communion deep ; and, in his spirit, range
> To lands far distant, into times of old,
> And view successive ages as they change :
> Strange countries and inhabitants as strange—
> By Tiber, where the Kesars held their sway,
> Attic Ilissus, Nile, and sacred Gange ;
> Kingdoms and empires long since passed away,
> And kings and conquerors, the mighty of their day."
>
> *Alexander Cunningham.*[1]

ARCHÆOLOGY is a science which deduces a knowledge of past times from a study of their existing remains, and, by the identification of ancient sites, assists geographers to determine the physical changes which have taken place in a country. Unfortunately, it has attracted few military engineers in India. Although a number seem to have studied the subject when opportunity offered, only two became specialists in it—Colonel Colin Mackenzie in the south, and Major-General Sir Alexander Cunningham in the north. Several others, however, were employed in tabulating and repairing ancient monuments, and, by their efforts in these directions, assisted the Government archæologists and gathered some knowledge of their work ; but they were archæologists only by inclination and not by profession, and their study of the intricacies of an ancient science lasted at most for a few years.

Those Engineers who came in touch with archæology in India soon discovered that it provided a wide range of interests and generated most heated arguments : that it was a sea into which any amateur might throw a line and catch a remarkable fish, and that the arguments which ensued as to whether the fish was valuable or worthless formed a pleasing relaxation on sultry evenings. Every year, archæology is now increasing in popularity as a subject for lectures. " Once," writes a modern expert,[2] " I attended a lecture given by that prince of archæologists, Mr. C. Leonard Woolley, on his excavations at Ur of the Chaldees. A lady in the audience then told me that she had already looked up ' ur ' in the dictionary and found it was ' a hesitation in human speech.' " This was her modest contribution to archæological research. But in India, as in England, there have always been a number of amateur antiquarians

[1] Major Alexander Cunningham, B.E., in *The Bhilsa Topes* (1854), p. 366.
[2] " An Archæologist's Memories," by D. T. Smith, appearing in *Blackwood's Magazine*, February, 1934, p. 210.

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who pursue their hobby with commendable energy and intelligence, and it sometimes happens that their discoveries in the field point the way to the professional.

Most of the early military students of archæology were officers of the Indian Infantry whose artistic talents, and interest in history, led them to examine and copy the ancient monuments and inscriptions which they saw around them. Whether they happened, as was so often the case, to be travelling by road from one part of India to another, or were settled in a civilian appointment in some remote district, they found that archæological exploration was an absorbing hobby. Some officers, with marked artistic ability, were selected by Government for the definite duty of copying inscriptions; but others, with no such aptitude or inclination, were ordered to report on ancient remains. There seems to have been little continuity of policy and much wasted effort. The results of years of strenuous endeavour were allowed to moulder in headquarter offices. These afflictions were shared by the few amateur archæologists who existed in the ranks of the military engineers of olden days; but the Engineers suffered less discouragement than their brethren of the Line because their efforts were more spasmodic and could only be made during brief intervals in their professional duties of surveying and building. "Much of ancient history still remains mere guess-work," said Lord Curzon in 1900.[1] "But the clues are lying everywhere at our hand, in buried cities, in undeciphered inscriptions, in casual coins, in crumbling pillars and pencilled slabs of stone. They supply the data by which we may reconstruct the annals of the past and recall to life the morality, the literature, the politics, the art of a perished age."

Archæological remains were subjected in India, as elsewhere, to the grossest vandalism. Historic buildings were put to ignoble uses, and antiquities were appropriated as they came to light. Sculptures, rings, coins, engraved seals, gems and other relics were carried off, first by invading hordes, then by dishonest rulers or casual robbers, and then, alas, by some of our own countrymen to adorn their houses and gardens. The demand for such objects became so great that Indians searched for them everywhere, and owing to random excavations, sculptures became mixed and their history and meaning were lost. For some years, the statues of two royal personages, coated with blacking to make them shine, formed the jambs of a fireplace in a regimental Mess. As far back as 1784, the Resident at Malda suggested that his new church should be paved with stones torn from the ruins of the ancient capital at Gaur. It is said that, between the years 1828 and 1835, a suggestion was made that the Sikandra Gardens near Agra should be leased for growing vegetables.[2] Some

[1] *The Life of Lord Curzon*, by the Rt. Hon. The Earl of Ronaldshay, Vol. II, p. 331.
[2] *Report of the Curator of Ancient Monuments in India*. 1881–82, p 5.

utilitarian officer once used an inscribed pillar of Asoka to roll the roads in Allahabad.

When the Sikhs ruled the Punjab they showed no respect for Muhammadan monuments. They used the Mughal Palace at Lahore,[1] Jahangir's Tomb at Shahdara, and other Imperial buildings, as quarries for material to build their "Golden Temple" at Amritsar. Marble screens, canopies and tessellated pavements were removed, and priceless relics defaced. The British were not such despoilers; but after their annexation of the Punjab in 1849, they had to face heavy expenditure in meeting the administrative requirements of the new province, and in providing barracks for troops. So it came about that they followed, to some extent, the example of their predecessors, the Sikhs, in putting the Mughal buildings to utilitarian uses. Officials were allowed to do much as they liked with interesting and valuable relics of antiquity. At Delhi in 1857, after the defeat of the mutineers, a proposal was put forward that the Jama Masjid should be demolished by the British engineers as an act of retribution. Happily, it was vetoed by Sir John Lawrence. Even in 1885, a French archæologist remarked that 40,000 cubic feet of stone from the ruins of the temples and palaces forming the ancient city of Chandravati in Gujarat had been removed by railway contractors. Before archæological restoration was undertaken by Government, paintings faded from walls, sculptured buildings were destroyed by the growth of trees or the ruthless hand of man, coins and inscriptions were stolen, mislaid or effaced, and everything suffered from the effects of weather. The ruins of ancient India were falling to dust.

Lord Curzon resolved to end this lamentable state of affairs. He made it clear, at the very beginning of his tenure as Viceroy, that he was determined to preserve and restore the architectural heritage of India, and that he would suppress vandalism with an iron hand. All who had obtained a footing in buildings of antiquarian interest were ruthlessly expelled. A Traffic Superintendent of the North-Western Railway hurriedly vacated the lovely Dai Anga Mosque at Lahore, and Christian congregations ceased to worship in the Choti Khwabgah.[2] A club and a post office were removed from the gilded Palace of King Mindon in Mandalay, a Police officer from a mosque in the famous fort at Vellore in Southern India, and a resident official from a marble pavilion at Ajmer. When Curzon came to India in 1899, the annual expenditure on the restoration and repair of ancient monuments was only £7,000; but when he left the country in 1905 it was in the

[1] Lahore Fort.

[2] The Choti Khwabgah is in Lahore Fort. It is of white marble, the roof supported by pillars and arches. From it, Shah Jahan issued orders daily to his nobles assembled below. The Dai Anga Mosque, dating from 1671, lies near the Grand Trunk Road leading from Lahore towards Shalamar. It is the mausoleum of Dai Anga, foster-mother of Shah Jahan and nurse to his daughter, Sultana Begum.

neighbourhood of £40,000, and on the Taj Mahal alone he had spent altogether nearly £50,000.

In fairness to some of his predecessors it should be remarked that Lord Curzon was not alone in showing respect for the monuments of the past, although no previous Governor-General had displayed his wholehearted enthusiasm. India is indebted to the Earl of Minto (1807–13), the Marquess of Hastings (1813–23), Lord Amherst (1823–28), Lord Auckland (1836–42), Lord Canning (1856–62), and others of more recent times, for the present state of preservation of some of her antiquities. For instance, in 1808 the Earl of Minto appointed a Taj Mahal Committee who employed Lieutenant Joseph Taylor, of the Bengal Engineers, to execute repairs to that wonderful memorial exceeding one lakh of rupees in cost. Again, in 1815, Lord Hastings instituted repairs to many historic buildings at Fatehpur Sikri and Sikandra near Agra, Joseph Taylor being placed in charge of the work and residing at Sikandra. Eleven years later, Lord Amherst appointed Captain Robert Smith, B.E., to repair the noble tower, outside Delhi, known as the Kutb Minar. All these buildings were constructed by Muhammadans. Lord Curzon, however, not only " recovered and renovated the dwellings in life, and the resting-places in death, of those master builders, the Mussulman Emperors and Kings," but extended his patronage to the secular and religious handiwork of every race and creed. He initiated a new era of activity in the Archæological Survey Department founded by Lord Canning in 1862, and he recruited trained archæologists and architects to further his ambitious projects. In these schemes, however, the military engineers of India had no part ; they had long since been recalled from archæological work to their normal duties in peace and war.

The birth of archæology in India may be said to date from the foundation of the Asiatic Society in Calcutta by Sir William Jones in 1784. Jones, who was a Judge of the Supreme Court and the first English scholar to learn Sanskrit, presided over the Society until he died ten years later. He was assisted by Sir Charles Wilkins and Henry Colebrooke, both of the Bengal Civil Service, the latter being not only an orientalist but a botanist, geologist, mathematician and astronomer.[1] Other learned and accomplished scholars who succeeded Jones were Francis Gladwin (Resident at Patna in 1808), William Chambers, Dr. Buchanan Hamilton, an experienced explorer, and Dr. Horace H. Wilson, Assay-Master at the Calcutta Mint, who was the greatest Sanskrit scholar of his day and an historian, linguist, chemist, numismatist, actor and musician.[2] The researches of these

[1] Henry T. Colebrooke helped to found the Royal Asiatic Society in England in 1823. He was President of the Asiatic Society in Calcutta from 1807 to 1814, when he left India. He died in 1837.

[2] Dr. H. H. Wilson who, like Sir William Jones and Sir Charles Wilkins, became a Fellow of the Royal Society, arrived in Calcutta in 1808. He was Secretary to the Asiatic Society of Bengal from 1811 to 1832, when he left India. He died in 1860.

enthusiasts were facilitated by the drawings of ancient remains made by the artists Thomas and William Daniell and James Wales. With the exception of Francis Gladwin, who served in the Bengal Native Infantry, all these men were civilians.

However, soldiers began to take a casual interest in archæology when the leaders of the Bengal Asiatic Society showed the way, and one of the first to do so was Lieut.-Colonel Anthony Polier, a Bengal Engineer who had been in charge of the building of Fort William in Calcutta from 1762 to 1764.[1] He was of French extraction, and his Christian names were really Antoine Louis Henri. Captain Polier, having proved a failure in Fort William, resigned from the East India Company's service and afterwards joined the armies of the Nawabs of Oudh and the Mughal Emperor at Delhi. Having been made a Lieut.-Colonel by Lord Hastings, with permission to live at Lucknow, he proceeded to write historical memoirs and to study Hindu mythology and poetry, being the first European to obtain a complete copy of the sacred Vedas. It seems that he also studied archæology, for he wrote an interesting description of the famous Buddhist pillar known as the "Firoz Lat," and the inscriptions found upon it, before he left India in 1788. He came to a tragic end, being murdered in Europe in 1795.

Infantry officers added a modest quota to archæological knowledge in the early days. For instance, in 1794 Major Moor described the grand Muhammadan ruins at Bijapur, the so-called "Palmyra of the Deccan"; and in the following year Captain Fell translated inscriptions on ancient monuments at Benares and Hissar containing genealogies of Indian dynasties, while Lieutenant Price translated a Sanskrit inscription in Bundelkhand.[2] Captain Sydenham made a careful survey of the Bijapur ruins in 1811; and a few years later Captain W. H. Sykes,[3] of the Bombay Infantry, wrote accounts of them and of the Ellora Caves. In 1832, Captain Harkness published an account of some cairns which he had found in the Nilgiri Hills, his report being elaborated by Captain Congreve in 1847. Lieutenant Burt, writing in 1834, described a Buddhist stone pillar at Allahabad which was said by the Hindus to be the club with which their hero, Bhima, had ground his *Bhang*.[4] Lieutenant J. Postans, an Assistant Political Officer in Sind, took infinite pains during 1839 to secure exact facsimiles of rock-inscriptions by King Asoka on the sacred hill of Girnar in Gujarat; but, when he sent them to Calcutta, the manuscripts and cloth copies were thrown carelessly aside and allowed to rot in a godown. Such was the treatment often

[1] See Vol. I, Chapter VIII, p. 126.

[2] *A Memoir on the Indian Surveys*, by C. R. Markham, pp. 239, 240.

[3] Colonel W. H. Sykes retired in 1833 and afterwards became an F.R.S., an M.P., and Chairman of the East India Company. He wrote extensively on the ancient history, antiquities, statistics, geology, natural history and meteorology of India. He died in 1872.

[4] Arabic *hashish*. An intoxicating preparation of hemp.

accorded to the discoveries of earnest seekers after archæological knowledge.

Two military archæologists who deserve more than passing notice are Colonel Philip Meadows Taylor, of the Hyderabad State Army, and Major Robert Gill, of the Madras Infantry. Meadows Taylor entered the Nizam's service in 1824, and was correspondent of *The Times* in India from 1840 to 1853. He became Commissioner of Shorapur before he retired in 1860, and during his service in the Deccan devoted much attention to prehistoric archæology, and contributed many papers on it and ethnological subjects to Indian journals. He was a graphic writer. "My literary work has been a great pleasure to me," he wrote in 1874,[1] "but I can only write about people among whom I have lived. Had I known how to write about modern society, fast young ladies, *roué* young gentlemen, fair murderesses with golden hair, and all the sensation tribe, I doubt not I should have filled my pockets better."

Major Robert Gill was an antiquary, artist and sportsman who joined the Indian Army in 1842. The Court of Directors ordered that copies should be made of the frescoes in the Buddhist cave-temples at Ajanta in Hyderabad, and Gill was selected, on the recommendation of Colonel W. H. Sykes, to begin the task in 1845. He spent the remainder of his life, about 30 years, in executing this work. With infinite patience, labouring in feverish jungles and in dark recesses haunted by wild animals, he began by making full-size copies in oils of about thirty of the principal frescoes and sent them to England in 1855. Twenty-five of these works of art, which were exhibited in the Crystal Palace, were destroyed there by fire in 1866, but five at the India Office escaped. Undeterred by the unhappy fate of years of labour, Gill continued his investigations, beguiling his spare time with hunting big game, and with such success that, during his lonely years in the jungle, he is said to have killed more than 150 tigers, mostly on foot. His fame as a sportsman survived for half a century after his death in 1875.

Enough has been written of the activities of some of the early military archæologists outside the ranks of the Engineers. These officers far outnumbered the Engineer archæologists; but they never produced such experts as Colonel Colin Mackenzie and Major-General Sir Alexander Cunningham, whose achievements, and those of a few Engineers who assisted or succeeded them, may now receive attention.

Colonel Colin Mackenzie, C.B., F.R.S., whose portrait appears in Vol. I of this history, was a native of the island of Lewis. Little is known of his parentage, education or early life; but for some time before he came to India, he was employed by Francis, Lord Napier,

[1] *The Story of My Life*, by the late Colonel Meadows Taylor, edited by his daughter, Vol. II (1877), p. 369.

in collecting information about the knowledge of mathematics, and of logarithms in particular, possessed by the Hindus. Lord Napier required this information to assist him in writing a memoir of his ancestor, John Napier, the inventor of logarithms. However, before the memoir could be completed, Lord Napier died, and young Mackenzie then managed to secure an appointment as a Cadet of Engineers in the Madras Army, and came to India in 1782 with letters of introduction to the Governor and Mr. (afterwards Sir Alexander) Johnston, who was stationed in Madura. It appears that Mrs. Johnston was a daughter of the late Lord Napier, and had undertaken to carry on her father's memoir of the inventor of logarithms. She invited Mackenzie to help her in this project, and he went to Madura in 1783. His work in that city brought him into touch with several Brahmins whose archæological knowledge so impressed him that he was encouraged to begin the unique collection of manuscripts and information, bearing on the literature and history of India, for which he is now famous.

The motives which led Mackenzie to form his collection, and the means which enabled him to prosecute his researches, are best described in his own words. "The first 13 years of my life in India," he wrote in 1817,[1] "may fairly be considered as of little moment to the object pursued latterly in collecting observations and notices of Hindu manners, of Geography and of History. The circumscribed means of a Subaltern Officer, a limited knowledge of men in power or office, and the necessity of prompt attention to military and professional duties, could not admit of that undeviating attention which is so necessary to the success of any pursuit at all times, and much more so to what must be extracted from the various languages, dialects and characters of the Peninsula of India. In particular, a knowledge of the native languages could never be regularly cultivated in consequence of the frequent changes from province to province, from garrison to camp, and from one desultory duty to another. It was only after my return from the expedition to Ceylon in 1796 that accident, rather than design, threw in my way those means that I have since unceasingly pursued. The connexion then formed with one person, a native and a Brahmin, was the first step of my introduction into the portal of Indian knowledge. Devoid of any knowledge of the languages myself, I owe to the happy genius of this individual the encouragement and the means of obtaining what I so long sought. In the following papers you will observe that 15 different dialects and 24 characters were necessary for this purpose. On the reduction of Seringapatam in 1799, not one of our people

[1] Letter from Lieut.-Colonel Colin Mackenzie, C.B., M.E., to Sir Alexander Johnston quoted in a Reprint, dated 1882, of *The Mackenzie Collection. A Descriptive Catalogue of the Oriental Manuscripts and other Articles illustrative of the Literature, History, Statistics and Antiquities of the South of India, as collected by Lieut.-Colonel Colin Mackenzie, Surveyor General of India*, by the late H. H. Wilson, 2nd Edition, 1828.

could translate from the Canarese alone. At present we have these translations made, not only from the modern characters, but from the more obscure and almost obsolete characters of the *Sassanums* (or Inscriptions) in Canarese and in Tamil, besides what have been done from Sanskrit, of which, in my first years in India, I could scarcely obtain any information."

Colin Mackenzie was commissioned as an Ensign in the Madras Engineers in May, 1783, and for some years studied archæology and history when his engineering duties permitted such relaxation ; but he was called away in 1790 to take part in the Third Mysore War, and was in the field against Tipu Sultan until 1792. In the following year he was sent to the siege of Pondicherry, and in 1795 he joined the expedition to Ceylon, where he was Chief Engineer at the siege of Colombo in January, 1796.[1] We find him again as Chief Engineer, in command of 300 Pioneers, with the expedition to Manila in the Philippine Islands in 1797, and present, in 1798, at Hyderabad when the British disarmed a large contingent of French troops employed by the Nizam. Then came the Fourth Mysore War, in which he assisted in the siege and capture of Seringapatam. Although it is probable that he was able to collect antiquities and coins in Tipu's capital,[2] his statement that his archæological researches were much interrupted by military duty in his early years in India is certainly not exaggerated. However, when he was appointed, after the fall of Seringapatam in 1799, to survey the whole of the dominions of the late sovereignty of Mysore, an area of about 70,000 square miles, he was able once more to combine antiquarian research with his other duties, and did so until he completed the survey in 1809. The excellence of his surveying operations resulted in his appointment in October, 1810, as Surveyor-General of Madras.

But again his antiquarian researches were interrupted, for he was sent to Java in 1811 as Chief Engineer of the expedition against the Dutch,[3] and there he nearly lost his life. He landed on July 14th, with Lieutenant John Blakiston, M.E., and a party of sailors, to reconnoitre the approaches to Batavia. The two Engineers dressed themselves as seamen, and it is recorded that Mackenzie, who stood six feet two inches, cut a most ludicrous figure in a jacket and trousers which were much too small for him. Taking a Chinese guide and only four sailors with them, the officers approached a village, out of which there suddenly emerged a French officer with a large body of troops. Mackenzie and his companions took to their heels, closely

[1] See Vol. I, Chapter X, p. 171.

[2] Seringapatam was literally overflowing with curios and treasure. (See Vol. I, Chapter X, pp. 177, 178.) It may be interesting to mention that Major-General Sir H. F. Thuillier, K.C.B., C.M.G., late R.E., has in his possession one of the smallest coins in the world, taken from Mysore in Tipu's time. This is a four-anna (4d.) *gold* piece (a *fanum*) given to him by his father, Colonel Sir H. R. Thuillier, K.C.I.E., late R.E.

[3] See Vol. I, Chapter XIII, p. 232.

followed by the enemy, who fired on them as they ran. The fugitives reached the remainder of their party and the boats, and pulled for the open sea under a heavy fusillade during which Blakiston had a narrow escape from a musket ball which was found afterwards lodged in his oar exactly opposite the pit of his stomach.[1] It was fortunate, indeed, for Indian historical research that Mackenzie survived.

After the capture of Java, Mackenzie remained in that island until March, 1815, busily engaged in collecting and arranging the topographical, statistical, and military reports and surveys of the former Dutch Government, and investigating the history and antiquities of the locality. He seems to have become popular with his late enemies, and to have contributed articles to a journal published by the Batavian Society. Returning to India he was made a Companion of the Bath, on the extension of that Order to officers of the Company's service, and in 1816, after more than 30 years' work in the Madras Presidency, he was appointed Surveyor-General of India. Being then obliged to leave Southern India to take up his post in Calcutta, he set out with his literary and antiquarian collections, and the retinue of Brahmins whom he employed in arranging and translating his materials. He intended to prepare an exhaustive catalogue of the whole collection, and to collate the translations for publication, but unfortunately the work was impeded by the death or illness of many of his assistants. Becoming desperate, he wrote in 1817 to his friend Sir Alexander Johnston, and the latter tried to persuade the Court of Directors to allow Mackenzie to return on leave to England for three years, on full pay and allowances, in order that he might be able to arrange his valuable materials with the help of European savants. No steps, however, were taken by the Court. Disappointed and overworked, Mackenzie died near Calcutta in May, 1821, leaving untouched his catalogue, which age and failing health had prevented him from preparing. Thus passed a very remarkable man, and a pioneer of archæology in India.

Colin Mackenzie's vast collection of manuscripts, coins, and inscriptions on stone and copper, enabled the early history of Southern India and its dynasties to be understood and written. As triangulation furnishes an accurate framework for topographical surveying, so the landmarks fixed by the study of inscriptions and coins are essential guides to historical knowledge. It is said that Mackenzie visited almost every place of interest south of the Kistna River, and that he prepared over 2,000 accurate drawings of antiquities, besides facsimiles of 100 inscriptions, and copies of about 8,000 others in 77 volumes.[2] He assisted Colonel Mark Wilks by

[1] *Military History of the Madras Engineers and Pioneers*, by H. M. Vibart, Vol. I, p. 456.

[2] *A Memoir on the Indian Surveys*, 1875–1890, by C. E. D. Black, p. 321, footnote.

supplying him with information for his history of Mysore, and, before he left Madras for Calcutta, sent home seven folio volumes of materials relating to the geography and history of Southern India. The colossal number of notes, drawings and translations which he amassed is shown by the fact that his collection occupies no less than 570 pages in a catalogue of Oriental manuscripts prepared by the Rev. William Taylor.

Mackenzie was so thorough in his researches, and so meticulously accurate, that he dreaded announcing to the world any discovery which he had not investigated to the full. Although he wrote a number of papers, he was chiefly employed in collecting data, and the publication of most of his results had to be undertaken by others after his death. A large part of his collection was gathered personally; but when he could not take the field himself, he despatched his Indian subordinates to carry on the work and submit their reports to him. Some of these reports make curious reading. There is, for example, the following effusion by a certain Babu Rao:—[1] "I arrived on January 13th, 1817, at Verampatam where formerly Palia Raya and Ponia Raya built the city. It is said that their uncle, Raja Tondaman, had there a great fowl called Ponayen Savel. It was of the height of an elephant and ornamented with a large iron chain on its neck, and its strength was so great that it could throw down a house by the flapping of its wings. Raja Tondaman considered that some great danger would happen to his own fowls, and therefore killed the aforesaid Ponayen Savel with an arrow. Then Palia Raya made war with his uncle, and both lost their lives; upon which Ponia Raya, being greatly grieved, placed a large nail on the ground and sat down on the top, and so departed this life." The tale is not lacking in point; but it is doubtful whether it could have been of much value in antiquarian research.

So enthusiastic was Mackenzie that he spent a large part of his fortune in the pursuit of his hobby. Government defrayed his personal expenses and those of his Indian assistants; but all extra expenditure, and the cost of all purchases, fell on Mackenzie himself, and it is said that these had amounted to more than £15,000 at the time of his death. Fortunately for his widow, the Governor-General was allowed to purchase the collection from her for £10,000. It seemed likely, at one time, that much of Mackenzie's labour might be wasted, since the officer who succeeded him as Surveyor-General was not interested in archæology; but Dr. H. H. Wilson eventually undertook to examine and report on the huge collection, and the manuscripts and other articles were transferred to his charge. A large portion of the collection was afterwards sent to England, where

[1] Reprint, dated 1882, of *The Mackenzie Collection, as collected by Lieut.-Colonel Colin Mackenzie*, by the late H. H. Wilson, 1828, p. 602.

it forms, to this day, a fitting monument to the extraordinary industry of one of India's most notable military engineers.[1]

The loss to archæology through Colin Mackenzie's death was soon compensated by the appearance of another enthusiast in the person of Mr. James Prinsep,[2] at that time an Assay-Master in the Benares Mint. Prinsep was transferred to the Calcutta Mint in 1830, and there, as Secretary to the Bengal Asiatic Society from 1832 to 1838, devoted himself to antiquarian, numismatic, mineralogical and meteorological studies. Modern archæologists owe much to his industry in deciphering the edicts of the great Buddhist King, Asoka, and in fixing positive dates in early Indian history. His labours were seconded by a number of assistants, including Lieutenants Burt, Postans and Markham Kittoe, the last-named being Curator and Librarian of the Asiatic Society for several years. When James Prinsep died in 1840, he bequeathed to his countrymen in Bengal a legacy of archæological knowledge which helped them to carry on their researches with some success though with little encouragement from Government.

But already a new star was rising in the archæological firmament. A youngster named Alexander C. Cunningham, a son of Allan Cunningham, the poet, had joined the Bengal Engineers from Addiscombe in 1833, following in the footsteps of his brother, Joseph D. Cunningham,[3] who arrived in 1831. He served for a time with the Sappers and Miners, and then became an Aide-de-camp to Lord Auckland, the Governor-General, in Calcutta, where he met James Prinsep, and was inspired by him with a taste for antiquarian research.[4] After Prinsep's death, military service in the Gwalior Campaign and the First Sikh War prevented Alexander Cunningham from pursuing his hobby, and it was not until 1846 that opportunity came his way, when he was deputed, with the unfortunate Vans Agnew,[5] to fix the boundary between Ladakh and Chinese Tibet. In June, 1847, he again entered the Himalayas, with Captain (afterwards General Sir Richard) Strachey, B.E., and Dr. Thomson, on the same project, and it was this mission which laid the foundation of his fame. He embodied the results of his exploration in a volume called *The Temples of Kashmir*, and later in a report entitled *Ladakh, Physical, Statistical and Historical*, thereby earning the thanks of

[1] The manuscripts are in the India Office. The coins and other museum-objects are believed to be mostly in the British Museum or the India Section of the Victoria and Albert Museum. They were placed originally in the East India Company's Museum, which was located at India House in Leadenhall Street, and later at Fife House in Whitehall. Finally they were stored in the India Office until dispersed in 1880.

[2] James Prinsep was a brother of Captain Thomas Prinsep, of the Bengal Engineers. Five other brothers of this family served in India.

[3] Captain J. D. Cunningham, B.E., died in 1851. He was well known as the author of *A History of the Sikhs*.

[4] Lieutenant A. C. Cunningham, B.E., was A.D.C. to Lord Auckland from 1836 to 1840.

[5] See Vol. I, Chapter XVI, p. 299.

Government.[1] In 1848 he sketched out a plan for the formation of an Indian Archæological Survey Department, but in this he was premature. No such Department was formed until Lord Canning accorded his formal sanction in 1862.

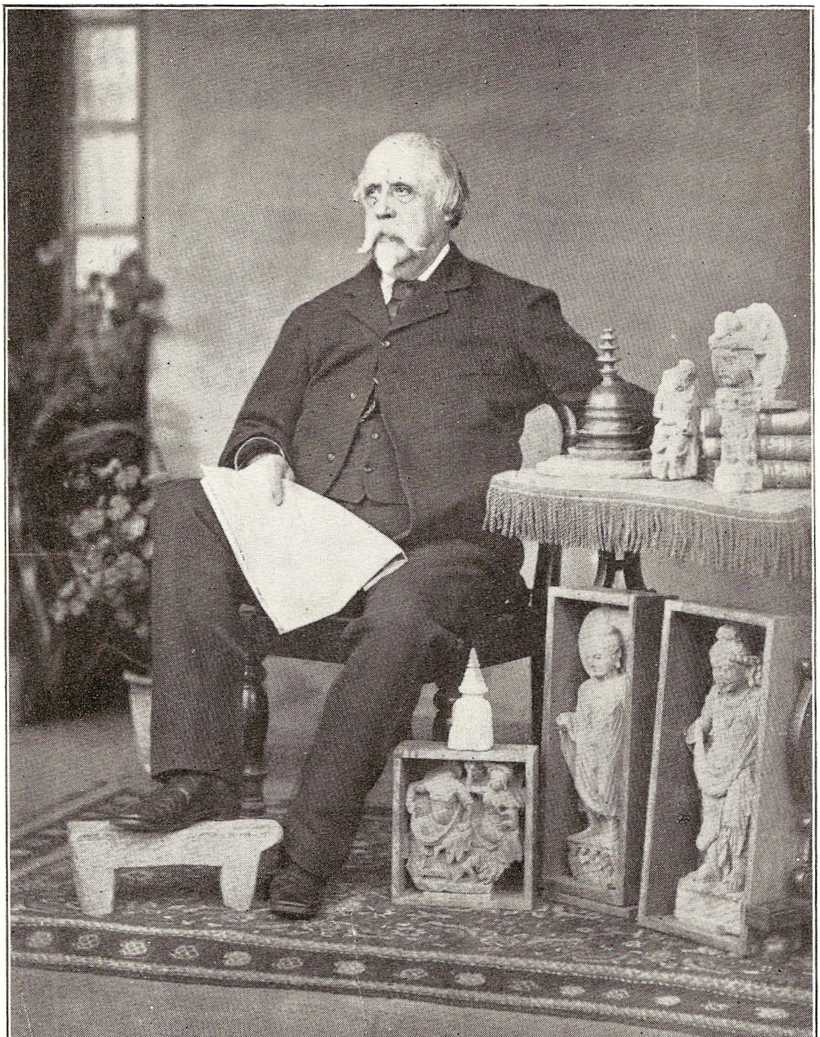
After his return from the battlefields of the Second Sikh War in 1849, Alexander Cunningham was posted as Executive Engineer at Gwalior, and there resumed his archæological studies. He was soon fortunate in meeting a brother archæologist in the person of Lieutenant (afterwards General) F. C. Maisey, of the Bengal Infantry, and together they explored the Buddhist monuments of Central India. Maisey had investigated the antiquities of Kalinjar in 1846–47, and having been told in 1849 by Captain J. D. Cunningham, B.E. (then Political Agent at Bhopal and himself a keen antiquarian), that interesting Buddhist remains existed at Sanchi near Bhilsa in the Bhopal State, he excavated at that place in 1849 and 1850.[2] There were about 30 *topes*, or mounds, in this neighbourhood, the largest of which was the Sanchi Tope, faced with masonry and some 42 feet high. Cunningham joined Maisey at Sanchi in 1851, and afterwards embodied the results of his labours in a volume entitled *The Bhilsa Topes, or Buddhist Monuments of Central India*, which he published in 1854.

In this book, Cunningham makes some interesting comments on the history of Buddhism. "The Buddhist religion," he remarks, "has long been extinct in India, but it still flourishes in Nepal and Tibet, in Burma, Ceylon and China, and amongst the Indo-Chinese nations of Annam, Siam and Japan. Its votaries far outnumber those of all other creeds except the Christian, and they form one-fourth of the human race. The valley of the Ganges was the cradle of Buddhism, which, from its rise in the sixth century before Christ, gradually spread over the whole of India. It was extended by Asoka to Kashmir and Kabul shortly after Alexander's invasion, and it was introduced into China about the beginning of our era by 500 Kashmiri missionaries. . . . In the middle of the seventh century, Buddhism was still the prevailing religion of the people (of India), but it was on the decline, and though it lingered about the holy cities of Benares and Gaya for two or three centuries later, it was no longer the honoured religion of kings and princes. It had become an old and worn-out creed. Yet its monasteries and temples remain; their paintings and sculptures still exist; their historical writings still live to attest the wonderful sway which a single enthusiastic individual[3] may succeed in establishing over the minds of the people."

[1] *The Temples of Kashmir* was published in 1848, and the volume on Ladakh in 1854. Alexander Cunningham wrote altogether about 13 unofficial volumes on archæological and numismatical subjects, and a number of official volumes and reports, and he superintended the writing of many others.

[2] *Sanchi and Its Remains*, by General F. C. Maisey (1892).

[3] Sakya, the first mortal Buddha, who died in 543 B.C.



MAJOR-GENERAL SIR ALEXANDER C. CUNNINGHAM, K.C.S.I., C.I.E.,
LATE BENGAL ENGINEERS.

Impressed, perhaps, by the value of Cunningham's publication, the Madras Government issued an order in 1857 that *all* their District Engineers were to report forthwith upon the ancient architectural remains in their several districts! This order was issued irrespective of the tastes and knowledge of the unhappy recipients, and naturally the results were disappointing, although the hard-worked Engineers did their best to become archæologists at a moment's notice. Lieutenant (afterwards Lieut.-General) John Mullins, M.E., described an ancient inscription on a tank at Nellore; Lieutenant (afterwards Major-General) H. L. Prendergast, M.E., wrote about the old fort at Arcot; and three infantry officers, in engineering employment, reported on other architectural remains and inscriptions. The scheme then faded gradually into oblivion. Archæology did not flourish during the Indian Mutiny, even in the peaceful south, though India continued to produce amateur archæologists after the rebellion had been subdued. The work of Major-General G. Le Grand Jacob, K.C.S.I., C.B., in transcribing Asoka inscriptions at Girnar after his retirement in 1861, of Colonel Sir Samuel Swinton Jacob, K.C.I.E., in describing the ancient buildings of Jaipur, and of Lieut.-General Sir Arthur Phayre, G.C.M.G., K.C.S.I., in writing on the coins of Burma in 1874, should not be forgotten. These are a few only of many examples of individual initiative.

Alexander Cunningham took no part in quelling the Indian Mutiny, for at that time he was Chief Engineer in Burma which he left in 1858 to occupy a similar post in the North-West Provinces of India. Retiring from the Army in June, 1861, with the rank of Major-General, he was appointed, in December, Archæological Surveyor to the Government of India, and charged with the control of the Archæological Survey Department which Lord Canning was about to create. His first work in his new sphere lay in the country bordering the Ganges and forming the ancient kingdom of Magadha, the home of Buddhism, where he trod in the footsteps of the early Chinese pilgrims and identified a number of ruins, especially at Buddha Gaya. During the following winter he laboured at Kalsi, Muttra and Delhi; and in 1863–64 he was engaged in identifying the cities and peoples of the Punjab as described in the expedition of Alexander the Great, and in viewing the scene of Alexander's battle with Porus on the Jhelum. Next he visited the ruins in nine of the ancient kingdoms of Hindustan to the south of the Jumna and, with that, his work came to an abrupt end. In 1866, during what has been aptly described as a cold fit of parsimony, Sir John Lawrence abolished the Archæological Survey Department. Cunningham then returned to England to busy himself with the publication of his *Ancient Geography of India* which enabled the world to understand the framework of Indian history.[1]

[1] *The Ancient Geography of India*, by Major-General Alexander C. Cunningham, was published in 1871.

However, public interest in the conservation of ancient monuments induced Lord Mayo, the successor of Sir John Lawrence, to re-establish the Department in 1870, and Cunningham was appointed Director-General in the following year. Thereafter, he made those discoveries of capital importance to Indian history and geography which he and his assistants recorded in 24 official volumes. He worked first in the two great capitals of the old Mughal Empire, Delhi and Agra, and in later years in the Punjab, the Central Provinces, Bundelkhand, Malwa, Bengal, Bihar and other territories.[1] For instance, in 1878–79 he was in the Punjab examining the sites of ancient cities reported upon previously by Generals Court and Ventura, foreign adventurers in the Sikh service under the old régime. In 1879–80 he was in Bengal; and in 1881–82 he visited the Central Provinces and framed an outline of their history from the third or fourth century of the Christian era down to the conquest of the country by the Marathas. At Muttra, in the United Provinces, he discovered a statue of Heracles strangling the Nemæan lion. It was a copy of some Greek original, and had been used for many years as a cattle-trough; but it was rescued from this ignoble employment and sent to the Calcutta Museum.

General Cunningham's last tours, between 1882 and 1885, were in Eastern Rajputana, Bundelkhand and Rewa. In September, 1885, being then in his 72nd year, he was allowed to resign his appointment as Director-General. His health had suffered through 52 years' service in India with only one intermission of any considerable length, and he wisely recognized the necessity of returning to his native land. The salient points of his archæological career may be summarized in his own words:[2] "I have identified the sites of many of the chief cities and famous places of ancient India, such as the Rock of Aornos, the city of Taxila, and the fortress of Sangala, all connected with the history of Alexander the Great.[3] In India I have found the sites of the celebrated cities of Sankisa, Sravasti and Kausambi, all intimately connected with the history of Buddha. Amongst other discoveries I may mention the Great Stupa of Bharhut[4] on which most of the principal events of Buddha's life were sculptured and inscribed. I have found three dated inscriptions of King Asoka, and my assistants have brought to light a new pillar of Asoka and a new text of his Rock edicts in Baktrian characters. I have traced the Gupta style of architecture in the temples of the Gupta kings at Tigowa, Bilsar, Bhitargaon, Kuthera and Deogarh, and I have discovered new

[1] It is interesting to note that in April, 1873, the whole of the 8th Company, Bengal Sappers and Miners, was employed on "Archæological Survey" at Mardan, near Nowshera, in the Peshawar District. (*History and Digest of Service, 1st K.G.O. Sappers and Miners*, p. 31.)

[2] Extract from *A Memoir on the Indian Surveys*, 1875–90, by C. E. D. Black, p. 337.

[3] Some of Cunningham's identifications have been disproved by the modern discoveries of Sir Aurel Stein. For instance, Alexander's Crossing of the Jhelum has now been identified as near Rasul, south of Cunningham's site, and Aornos as at Pir Sar, north of Cunningham's location,

[4] Bharhut lies about 120 miles S.W. of Allahabad. A *stupa* (Sanskrit) is a mound, often faced with masonry.

inscriptions of this powerful dynasty at Eran, Udaygiri and other places." It may truly be said that few original investigators have reaped so rich a harvest as Cunningham, or have left behind them a more devoted circle of disciples and friends.

On General Cunningham's retirement the Archæological Survey Department was reorganized on a plan proposed by him and was placed under the control of Dr. James Burgess. In accepting Cunningham's resignation, the Government expressed their thanks to him for his distinguished services, and soon afterwards he was created a K.C.S.I. and awarded a special pension. He continued working to the last at his favourite study of Indian archæology, and though confined to his room in his flat in London, managed to complete five papers and a small book on Indian coins. Professor E. J. Rapson of Cambridge states that he used often to visit Cunningham on Sunday afternoons to discuss Indian numismatics.[1] The end came on November 28th, 1893, when Cunningham died at the ripe age of 80 years. His eldest son, Lieut.-Colonel A. J. C. Cunningham, R.(B.)E., had then retired from the Corps; but his grandson, Lieutenant (afterwards Colonel) A. H. Cunningham, R.E., was worthily maintaining the reputation of a great name in the annals of India.[2]

During the last few years of his service, General Cunningham had an energetic assistant in Captain H. H. Cole, R.E., the only other officer of the Corps ever posted to the Indian Archæological Department, although several Royal Engineers carried out archæological excavation or conservation work under orders from other departments. In 1874–75, for instance, Lieutenants C. A. Crompton, Suene Grant, P. Haslett and C. Maxwell excavated in the Peshawar District; and between 1882 and 1885, Lieutenant H. E. S. Abbott repaired ancient buildings in Lahore, Delhi and elsewhere. Cole had dabbled in antiquarian work since 1868, when he visited Kashmir, and in 1869 he published a large volume of photographs and plans of the ruins in that country.[3] He was placed on special duty in April, 1880, to examine the condition of the ancient monuments in Lahore, Delhi and Agra. This he did, and during the following cold weather visited Lahore, Amritsar, Agra, Gwalior, Allahabad, Sanchi, Mandu, Ujjain, Benares and Jaunpur. In January, 1881, he was gazetted as "Curator of Ancient Monuments in India," being then instructed to inspect all the principal monuments in the country.[4] He travelled to many places in the Madras and Bombay Presidencies, and proceeding through Hyderabad, passed up Rajputana to Delhi. During

[1] Letter dated January 18th, 1934, from Professor E. J. Rapson to the author.

[2] Memoirs of Major-General Sir Alexander C. Cunningham, K.C.S.I., C.I.E., late Bengal Engineers, appear in *The R.E. Journal* of March, 1894, and in *Addiscombe, Its Heroes and Men of Note*, by H. M. Vibart, pp. 455–459.

[3] *Illustrations of Ancient Buildings in Kashmir*, by H. H. Cole, Lieut., R.E., Superintendent, Archæological Survey of India, North-West Provinces. (Presumably he was so appointed before the re-establishment of the Department in 1870.)

[4] *First Report of the Curator of Ancient Monuments in India*, 1881-82, by Captain H. H. Cole, R.E., Preface, p. 2.

July he examined the old fort at Delhi, and the Agra fort where Major W. Keith, R.E., Assistant Curator for Central India, was renovating some of the ancient buildings. Continuing his tour in February, 1882, he inspected buildings in the Peshawar District, and then, journeying by Gwalior, Agra, Buddha Gaya and Calcutta to Southern India once more, returned through Western India to Simla in April.

During the spring of 1883, Cole and his men collected and repaired sculptures in the Yusufzai District of the North-West Frontier where the architecture and ornament of the Pathan buildings showed the influence of Greek art. While Alexander's invasion had left examples chiefly of the Corinthian order of architecture in Yusufzai, Cole found that, in Kashmir, the Doric order predominated and, between Attock and Rawalpindi, the Ionic order.[1] Such beauty of conception, and such vigour of treatment, were apparent in some of the sculptures in Yusufzai, that it is evident that the Indian artists of Alexander's day had as fine a poetic feeling as that displayed by the pupils of the Bombay School of Art in their recent decoration of the India House in London.

General Sir Bindon Blood, in his volume of reminiscences entitled *Four Score Years and Ten*, makes some interesting comments on the Yusufzai remains which he observed during the Chitral Expedition of 1895.[2] According to him, in the time of the Græco-Buddhists, and until the arrival of the Pathans, the inhabitants of the Yusufzai Plain and neighbouring parts had arrived at a high level of prosperity and doubtless had become " too proud to fight."[3] They left numberless buildings, and among them a castle and accessory constructions at the Malakand Pass which was evidently one of their important defensive posts. They had also a cart-road leading through the Pass, and this road is still in existence. The Talash Valley, between the Swat and Panjkora, contained a surprising number of remains left by the Græco-Buddhist inhabitants. In one place Sir Bindon and his companions found a quantity of sculptured stone buried in a mound, and sent many valuable specimens to the Lahore Museum and elsewhere.

Cole continued his archæological tours during the winter of 1883–84, visiting many celebrated monuments and giving advice on their preservation. At the same time he noticed how modern Indian architecture was being modified by European influence.[4] A rich inhabitant of Muttra, who proposed to build a temple, had to send to Madras for a plan, although Muttra was once the centre of Hindu architecture. The result was an inferior interpretation of Dravidian

[1] *The R.E. Journal*, Vol. 13, 1883, p. 244.
[2] See Vol. I, Chapter XXI, p. 441.
[3] *Four Score Years and Ten* (1933), by General Sir Bindon Blood, G.C.B., G.C.V.O., Representative Colonel Commandant R.E., pp. 269 and 277.
[4] *The R.E. Journal*, Vol. 15, 1885, p. 230.

art. Cole found that a Maharajah in Bundelkhand had built himself a temple which resembled St. Pancras Church in London, and that two Maratha chiefs wished to have Indo-Italian palaces. Indian architects, for the design of temples, seemed to be scarce even in Madras. Much useful information was collected by Cole during his tours in 1883–84, but these proved to be his last. His connection with archæology was severed in March, 1884, when his appointment was abolished and he returned to his normal work as an Executive Engineer. Lord Dufferin had followed Lord Ripon as Viceroy, and had discovered that the finances of India were in a critical condition. Drastic retrenchments were made and the Archæological Department, being considered more a luxury than a necessity, suffered heavily.

Little remains to be recorded about the slender connection of Royal Engineers with archæology in India; yet no account would be complete without some mention of the work of Colonel H. E. S. Abbott, C.B.E., D.S.O., the only survivor of those who once tended the ancient monuments of the country. As an Assistant Engineer in the Public Works Department at Lahore in October, 1882, Abbott was placed in charge of the repair of the historic buildings in the Punjab, and found a valuable adviser in Colonel J. G. Medley, late R.(B.)E., the Consulting Engineer for Railways, who was interested in such work. At that time, the Principal of the Lahore School of Art and Curator of the Museum was John Lockwood Kipling, of the Indian Educational Department, the father of Rudyard Kipling. "He was a clever man at all Art work," writes Abbott,[1] "and of no mean literary attainments, though in these he was out-classed by Mrs. Kipling from whom it is evident that Rudyard has inherited his great talents. Lockwood Kipling told me all about the lost art of glazed tile work (*Kashi*) with which the brick surfaces of the old Fort walls at Lahore are covered, and which is said to have been executed by artists from China. I began my duties by touring about the Punjab, with Cole's reports to guide me, and found that most of the ancient buildings were left to their primeval solidity to remain standing. The Mughal Fort, or Palace, at Delhi, was naturally of the first importance. The white marble Diwan-i-Khas, or Public Hall of Audience, was one of the most beautiful of its buildings, but the roof was said to require careful examination. We discovered, above the gilded and painted ceiling, a very heavy roof-covering of a sort of concrete, about 3 feet thick, which seemed to be supported, across a span of 27 feet, by stout wooden beams at close intervals. On boring into these beams, however, we found, to our consternation, that they were utterly rotten and worm-eaten. The concrete was not only holding itself up as a monolithic slab, but was supporting the weight of the beams and ceiling in addition, and any earthquake tremor might have

[1] Letter dated February 1st, 1934, from Colonel H. E. S. Abbott to the author.

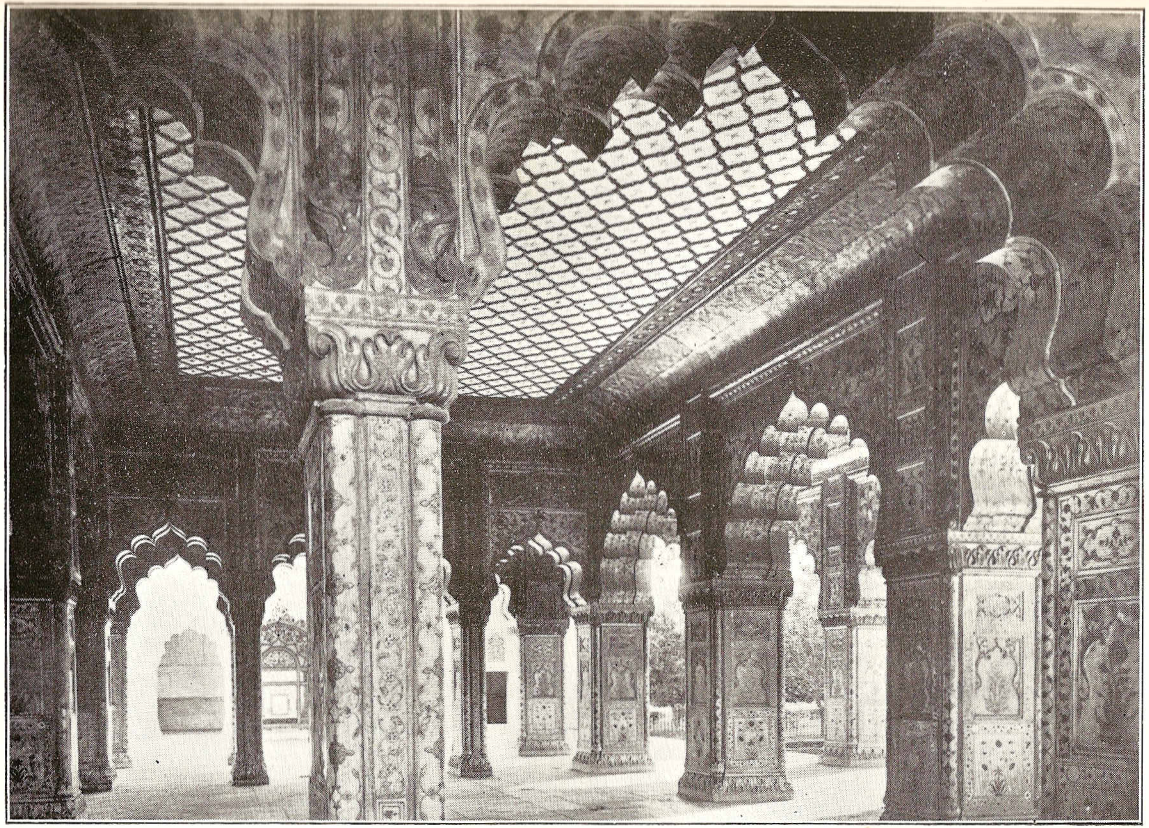
brought all down with a crash! The Hall was frequently used for large gatherings, and only a few years previously, King Edward VII,, as Prince of Wales, had held a grand Durbar there! Needless to say, I had a new roof put on at once. Without disturbing the ceiling, we introduced rolled steel beams and laid concrete over them."[1]

Continuing his reminiscences of repairs to the well-known buildings in Delhi Fort, Colonel Abbott says: "In the Diwan-i-Am, or Private Audience Hall, where the famous Peacock Throne once stood, we had to restore the wonderfully decorated panels of *pietra dura* work with the help of coloured drawings which Cole had obtained. Originals had been hacked out and removed on various occasions by robbers, and, in Mutiny days, by our own soldiers. This marble inlay work was introduced originally by a Florentine adventurer in Shah Jahan's time, and had been adopted by the artisans at Agra, so I went to that city and gave a trial order which was very well executed. But the Agra workers, expecting a large amount of work, then formed a ring and raised their prices enormously. Accordingly, I sent a coloured plaque to Florence, where the work was done so beautifully that I repeated the order. Then I placed the Florentine examples in position at Agra, and boasted openly that we British could do inlay work quite as well as the Agra craftsmen! Down came the Agra prices, and reasonable terms were arranged. But our progress was very slow, and before much restoration could be done, orders came that conservation only should be undertaken. This was continued, though with ever-decreasing grants of money, until I was transferred to Simla, towards the close of 1884, to assist the local Executive Engineer. But not, alas, in any 'high art' work. I was required to help him in a sewage scheme! *Facilis descensus Averni.* This terminated my connection with Archæology."

By the end of 1885, with the departure of Cunningham, Cole and Abbott, the Corps of Royal Engineers ceased to be represented in the Archæological Survey Department or the conservation of ancient monuments. The Department continued to operate successfully under a series of able civilian archæologists. During recent years it has produced valuable results under the present Director-General, Sir John Marshall, C.I.E., in spite of a serious financial stringency which has curtailed many of its activities. It may be said to have reached the zenith of its prosperity, though not of its efficiency, in the affluent days of Lord Curzon.

Allied to archæology, which pictures the past through the handiwork of man, is the science of geology which elucidates the distant epochs before man appeared. This is a branch of study in which the military engineers of India have never attempted to attain more than

[1] Major H. H. Cole, R.E., the Curator of Ancient Monuments, refused to allow the ceiling to be repaired or renovated, as he considered that this would be an act of vandalism. Interference with the original ceiling was accordingly, and very cleverly, avoided.



THE DIWAN-I-KHAS, DELHI FORT, 1884.

a very modest proficiency, and few have gone even so far as that. During the early part of the nineteenth century, officers of the Indian Infantry seem to have displayed greater interest in it than Engineers, possibly because they had more time to devote to it.

Dr. Voysey, the surgeon who joined Lambton in his Survey Triangulation in 1818, was probably the first official geologist in India.[1] He was sent to reconnoitre the country as far as Agra, and afterwards worked with Everest on the Godavari and in the Deccan. Voysey was followed by other observers who described the rocks and minerals in different parts of India. Between 1820 and 1845, a number of men were at work. Captain Dangerfield reported on the geology of Malwa, and Captain Franklin on that of Bundelkhand; Colonel Sleeman discoursed on the fossils which he had found at Jubbulpore; Lieutenant Finnis described the rocks between Hoshangabad and Nagpur; Colonel Ouseley explored the Narbada coal region; and Captain T. J. Newbold, of the 23rd Madras Infantry, while Assistant Resident at Karnal, made careful geological sections across the Indian peninsula, and wrote a report about the whole region south of the latitude of Bombay. Newbold may justly be considered as the best geological observer of the early days.[2] In later years, other military officers devoted much time to geology. Captain Nicolls collected fossils at Saugor, Lieutenant Keatinge near the Narbada, and Captain Hutton in the Spiti Valley. General Cullen found beds of lignite close to Quilon, Captain Grant examined the strata in Cutch, and Lieutenant Aytoun reported on parts of the Southern Maratha country. The valuable contributions of Dr. H. J. Carter, of the Indian Navy, also deserve notice. Not only did he investigate the nature of the rocks of the Arabian Coast, and write on the geology of the islands of Bombay and Salsette, but he collected and classified the work of his predecessors.[3] These achievements suffice to show that, in pre-Mutiny days, geology was an absorbing pursuit to many officers who were not Engineers.

The scene of most of the geological work executed by military engineers in India lies in the Siwalik Hills which run parallel to the great chain of the Himalaya. These densely-wooded heights are the grave and monument of an early and distinct fauna; they originated, apparently, through the upheaval of a narrow belt of the plains, and seem to mark the beginning of the present epoch in India. As they pass within a few miles of Saharanpur, it was natural that the engineers who were employed long ago on the Eastern and Western Jumna Canals in that vicinity should find in these hills a convenient ground for geological research. An able and energetic leader was available in Dr. Hugh Falconer, the Superintendent of the Botanical Gardens at Saharanpur. Falconer had begun to explore the Siwaliks

[1] See Chapter XI, p. 192.
[2] *A Memoir on the Indian Surveys*, by C. R. Markham, p. 212.
[3] *Ibid.*, p. 215.

in 1831 in conjunction with Captain (afterwards Colonel Sir Proby) Cautley, of the Bengal Artillery, who was destined to become famous as the builder of the Ganges Canal.[1] These two enthusiasts laboured to such good purpose that in 1837 they were awarded the Woollaston Medal in duplicate by the Geological Society, and Cautley presented to the British Museum a collection of fossils which filled 214 chests and weighed some 40 tons.[2] Their success, however, was partly due to the enterprise of two young Bengal Engineers. Very early in his investigations, Falconer had proved that the Siwalik Hills belonged to the tertiary age; but he and Cautley had discovered few animal remains, although Cautley had gone to the trouble of carrying out blasting operations in likely places.

The Bengal Engineers who brought success to Falconer and Cautley were Lieutenants W. E. Baker and H. M. Durand. In 1833 they were Cautley's assistants on the Jumna Canals, and were doubtless encouraged by him to join in the search for fossil remains, though with little result for a time. It was known that these remains existed because Captains Herbert, Hodgson and Webb had found some specimens about 17 years previously; and in the fourteenth century the workmen employed by King Firoz III. had unearthed fossil bones which were said to be those of giants, three yards long! However, in October, 1834, Baker and Durand made a chance discovery which startled the scientific world and, within a few years, contributed materially to the study of palæontology. They had been hammering at the rocks near Nahan, the capital of the Sirmur State, and had obtained a few crocodiles' teeth which they proudly showed to the Rajah; but the latter merely smiled and sent for what he called his "Tooth of Deo," a molar weighing nearly 12 lbs. and belonging to a *Mastodon Latidens*.[3] At the same time he told them where to dig. Two days after they had got their first good specimens, Falconer arrived on the spot, and together they collected 300 specimens of fossil bones in six hours.

During the next two or three years Falconer, Cautley, Baker and Durand amassed the remains which Cautley afterwards sent to England, thereby bringing to light a sub-tropical mammalian fossil fauna, unrivalled in richness and extent, and including the bones of many extinct species of colossal animals. All the mammalian remains belonged to extinct species; but some of the reptilia and fresh-water shells were identical with existing forms, and from this fact Falconer was able to draw important inferences as to the antiquity of the human race. Baker presented the Natural History Museum at South Kensington with two gigantic tusks of a fossil

[1] See Chapter I, pp. 5-10.

[2] Both Falconer and Cautley also wrote many papers on geological subjects for the Bengal Asiatic Society and the Geological Society in London.

[3] *The Life of Major-General Sir H. M. Durand, K.C.S.I., C.B.*, by H. M. Durand (1883), Vol. I, p. 36.

elephant, each 11 feet in length. Cautley sent a description of a fossil giraffe to the Journal of the Asiatic Society of Bengal; and Falconer and Durand wrote on the fossil remains of camels, tigers and bears. The plates illustrating these articles were prepared mostly by Durand, who became an expert, though self-taught, engraver on copper. From this time forward, Durand was a keen geologist; but his political and other duties in later years left him little leisure for his hobby. Cautley became immersed in his gigantic canal operations; Baker's energies were absorbed afterwards, in railways and other public works; and so the little band of amateur geologists in the Siwalik Hills was scattered to the four winds.

However, Cautley's example inspired Lieutenant (afterwards Lieut.-General Sir Richard) Strachey, B.E., to study fossil remains in the Siwaliks when he was appointed as an assistant on the Ganges Canal construction in 1843; and although Strachey was called away in 1845 to the First Sikh War, he resumed his explorations on his return in the following year. Malaria then beset him, and he was obliged to go to the hill-station of Naini Tal in 1847 to recuperate while Lieutenant Henry Yule, B.E., carried on his canal duties. Yule, no doubt, explored the Siwaliks, but archæology and geography were more to his taste than geology.[1] At Naini Tal, that picturesque spot where bungalows cluster around a blue lake 6,000 feet above the sea, Strachey made the acquaintance of Major E. Madden, of the Bengal Artillery, and under his guidance devoted his time to the study of geology and botany, both from books and in the field. An opportunity to put his knowledge to practical use came in 1848 when he journeyed into Tibet with Mr. J. E. Winterbotham. Together they made a large collection of species, and established the fact that there were, in Kumaon, glaciers similar to those of the Alps. Richard Strachey's geological investigations proved the existence of a great series of palæozoic beds along the line of the passes into Tibet, with Jurassic and tertiary deposits overlying them. He traversed some of the highest passes as far as the Manasarowar lake region, visited two years previously by his brother Henry. In 1850 he returned to England and spent the next five years in arranging and classifying his Kumaon collection, which brought him a Fellowship of the Royal Society.

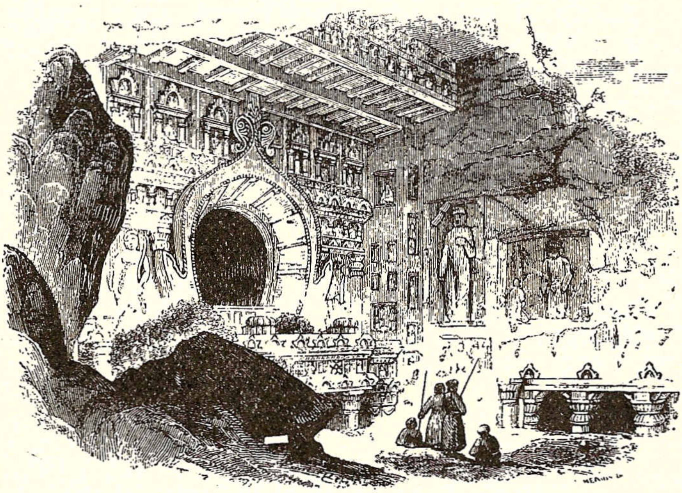
In those days geology was under a cloud. It is a fact that when Dr. Thomas Oldham arrived in India in 1851 as the newly-appointed Superintendent of the Geological Survey, and began his service of 25 years' duration in that post, the establishment which he found consisted of one clerk and a *chuprassi*. The activities of the Department were bounded by the four walls of a small office. Oldham

[1] Sir Aurel Stein, K.C.I.E., dedicated his *Ancient Khotan* to Henry Yule as "the greatest elucidator of early travel and a pioneer of the historical geography of Central Asia." Yule wrote many books and papers on Archæology and Geography in addition to his masterpieces, *The Travels of Ser Marco Polo* and *Hobson Jobson.*

secured the services of Mr. J. G. Medlicott and another European assistant; but the only idea which the Government then had of the duties of a geological surveyor was that he should tour from place to place and report upon real or imaginary discoveries of minerals. Conditions improved when Lord Canning reorganized and expanded the Department in 1856; and from that time, under Oldham, Medlicott,[1] and others of a long line of expert geologists, it has prospered and done valuable work in advising engineers engaged in railway, irrigation, mining, water-supply and similar undertakings. Since the days of the Indian Mutiny, few Royal Engineers have been able to devote much attention to the study of geology, although in 1911 Lieut.-Colonel R. F. Sorsbie, R.E., produced an excellent book for the use of engineers, the writing of which had occupied him for 14 years.[2] In planning the Khaibar Railway after the Great War, Lieut.-Colonel (now Colonel Sir) Gordon Hearn, D.S.O., R.E., found that the geological knowledge which he had acquired stood him in good stead, and others have had a similar experience; but, broadly speaking, it may be said that in India the science of rocks and fossils is now studied only by civilian professionals. The military engineer has had his day in this as in so many other pursuits which lie outside his duty as a soldier.

[1] Mr. J. G. Medlicott followed Oldham as Superintendent in 1876. He was a brother of Mr. H. B. Medlicott, Professor of Geology at the Thomason College, Roorkee.

[2] *Geology for Engineers*, by Lieut.-Colonel R. F. Sorsbie, R.E. (now Brig.-General R. F. Sorsbie, C.B., C.S.I., C.I.E.).



EXTERIOR OF CHAITYA CAVE, ADJUNTA.

CHAPTER XV.

TELEGRAPHS.

ALTHOUGH signalling by means of electricity was carried out by Lesage at Geneva as early as 1774, it was not till 1837 that the work of Wheatstone and Cooke in Great Britain, and of Morse and Vail in America, gave birth to the electric telegraph. When the first British telegraph line, upon Wheatstone's plan, was erected in 1839 between London and Slough, a pioneer was already at work in India on the problem of electrical communication, for Dr. (afterwards Sir William) O'Shaughnessy, of the Bengal Army, was then building an experimental line, 21 miles in length, in the Botanical Gardens outside Calcutta. O'Shaughnessy conducted many experiments with his primitive line, and finally proposed to transmit signals in an ingenious, though impracticable, way. At each end of his line he placed a clock, the two being kept in synchronism, and over the dial of each moved a seconds' hand pointing to different letters of the alphabet. When the pointer arrived at the desired letter, the sender transmitted an electrical shock, and the receiver, noting the position at that moment of the pointer at his end, read the letter. O'Shaughnessy's experiments were valuable because they proved that electric telegraphs could be worked over considerable distances; but the public remained aloof, and for several years regarded his efforts with contemptuous scepticism. In time, however, opinion changed, and the Bengal surgeon was entrusted with the erection of a telegraph line from Calcutta to Diamond Harbour, 30 miles to the south, which he opened in December, 1851. The electric telegraph saved India in the Mutiny of 1857. It is difficult, indeed, to estimate what England owes to the persistence and courage of her first Superintendent of Telegraphs in Bengal.

In 1852 the Court of Directors sanctioned the construction of telegraph lines from Calcutta to Peshawar, Bombay and Madras, but further investigation caused some modification of the original scheme. It was decided that a northern line should follow the valley of the Ganges to Allahabad, running thence through Agra and Delhi to Lahore, and finally to Peshawar, with a branch line from Ambala to Simla. Connection between Calcutta and Bombay was to be established by a line taking off from the northern line at Agra and running southwards through Indore and Nasik; while between Bombay and Madras there was to be a direct line across the Deccan.

Early in 1853, O'Shaughnessy began to organize the work in Bengal and then sailed for Europe to arrange for the rapid shipment of materials and stores. He secured the appointment of Dr. Green as Assistant Superintendent in Bombay, and in December the latter began to carry a line from Bombay northwards towards Agra, while other parties, under his direction, co-operated at various sections as far as Indore. By May, 1854, electric communication was established between Bombay and Calcutta, and in the following year between Bombay and Madras. The lines differed greatly from those in England, chiefly in the size of the wire employed. English practice favoured No. 8 gauge wire, $\frac{1}{6}$-inch in diameter and weighing about $\frac{1}{5}$-ton per mile; but in India the wire was so thick that it might almost be termed a rod, being of No. 1 gauge and weighing $\frac{1}{2}$-ton per mile.[1] Most of the heavy Indian lines were supported on stout bamboos instead of wooden poles. In 1856 telegraph lines stretched from Calcutta to Peshawar (1,600 miles), from Agra to Bombay, and from Bombay not only to Madras but to Mysore and the hill-station of Ootacamund in the extreme south;[2] and by the year 1872 every important place was connected by telegraph, while additional lines also followed the 5,373 miles of railway then opened. It is unnecessary to trace in detail the further growth of telegraphs in India. The country has been gradually covered from end to end and side to side by a network which now incorporates more than 100,000 miles of line.

The entry of the military engineer into the field of Indian telegraphy occurred in May, 1853, when Lieutenant (afterwards Lieut.-Colonel) Patrick Stewart, of the Bengal Engineers, was appointed Superintendent of Electric Telegraphs in the absence of Dr. O'Shaughnessy in Europe. Stewart found much to surprise him. "The lightning has come into the offices several times lately," he writes, "destroying parts of the instruments completely and sounding all the alarms. On the lower parts of the line, near the Bay, there are immense numbers of wild buffaloes that continually come to rub themselves on the posts, and not unfrequently knock them down. Great numbers of birds have been killed, while sitting on the iron rods, by flashes of lightning passing along them." Besides making tours of inspection, Stewart had to arrange for the transmission of stores and instruments for the whole line from Calcutta to Lahore, and for the Bombay line from Agra to Indore, where his men would connect with the parties under Dr. Green. He had also to send materials for a line from Prome, on the Irrawaddy in Burma, to the Arakan Coast at Sandoway. In October he was appointed Aide-de-camp to the Lieutenant-Governor of the North-West Provinces, but

[1] *The Electric Telegraph in India* (1853), by W. B. O'Shaughnessy, Surgeon, Bengal Army, p. 29.

[2] *First Report on the Operations of the Electric Telegraph Department in India* (February 1st, 1855, to January 31st, 1856), p. 45.

nevertheless continued to control the telegraph operations until O'Shaughnessy returned.

Patrick Stewart's work was largely administrative. He held the post for O'Shaughnessy, and held it well; and his services, in a difficult position, did not go wholly unrecognized. A writer in *The Friend of India*, dated April 6th, 1854, remarked: "There is one officer who has been concerned in the successful introduction of the Electric Telegraph who has never received his due meed of approbation. To Mr. Stewart, while acting as Superintendent of the experimental line, is due the credit of making all those arrangements which are so essential to success. His task was by no means light. The line was to be extended at once to Lahore, a distance of 1,280 miles, and Dr. O'Shaughnessy had expressed a wish that depots should be established at seven different places. Forty artificers arrived. Then came tons of wire, besides machines for straightening the lines. Hundreds of thousands of posts were to be fixed at equidistant places along this immense line, and all were to be grooved. Lastly, all this was to be effected in a country where there is but one road and no railways, where delay is a habit, and by an officer with no authority over anyone except his signallers, and so young that his appointment was received with a feeling of surprise. By dint of endless correspondence, all was placed in train. The artificers were despatched by steamer to the depots. The wire was carried by steamer and bullock carts to 32 different places between Calcutta and Benares alone. There was not, we believe, a blunder or a single day's delay; and when Dr. O'Shaughnessy arrived he was able to drive on the work as rapidly as if he himself had been upon the spot." In these few months, while officiating for O'Shaughnessy, young Patrick Stewart laid the foundation of a remarkable telegraphic career.[1]

Since the days of Patrick Stewart only five military engineers have been concerned in the development and operation of the civil telegraph system of India. Such work entails administrative duties and specialized knowledge which are normally outside the range of the soldier. A notable exception occurs, however, in the case of Colonel D. G. Robinson, C.B., late Royal (Bengal) Engineers, who was appointed Director-General of Indian Telegraphs in 1865. During his tenure of 12 years, the telegraphs spread over India and were connected by overhead and submarine cables with England. His zeal, activity and marked administrative ability enabled him to place the Indian Telegraph Department on a thoroughly sound footing. He took a leading part in the deliberations at Berne in 1871,

[1] A very complete memoir of Lieut.-Colonel Patrick Stewart, C.B., Royal (Bengal) Engineers, appears in *Telegraph and Travel* (1874), by Colonel Sir Frederick J. Goldsmid, K.C.S.I., C.B., pp. 9–59. Memoirs appear also in *Addiscombe. Its Heroes and Men of Note*, by H. M. Vibart, pp. 581–586; in *Biographical Notices of Officers of the Royal (Bengal) Engineers*, by Colonel Sir E. T. Thackeray, V.C., K.C.B., late R. (B.) E., pp. 169–174; and in the *Geographical Magazine*, October, 1874.

and in the international conferences on telegraphic communication which were held in Rome and St. Petersburg, and his death in 1877, while on his way to England, was a heavy blow to telegraphic progress in the East.[1]

The records of the Indian Telegraph Department show that four other military engineers, besides Robinson, took part in its operations. In 1866, and part of 1867, Lieut.-Colonel T. G. Glover, Royal (Bengal) Engineers, acted as Director-General during the absence of Colonel Robinson, and after retiring as a Colonel in 1870, became a director of several Eastern and African telegraph companies and visited Australia in connection with a duplicate cable to that country. Major P. Murray, Royal (Bengal) Engineers, acted as Director-General for a few months in 1867 and 1868. Major John Eckford, of the same Corps, alternated from 1869 and 1880 between the posts of Director of Construction and Superintendent of Stores and Workshops, and is said to have reorganized the Workshops very effectively.[2] Lastly we find the name of Major F. G. Oldham, R.E., who was Examiner of Telegraphic Department Accounts from 1881 to 1884; but with Oldham's departure the connection of military engineers with civil telegraphy ceased except for the attachment of young officers, between 1890 and 1907, for training in the Indian Telegraph Department.

Although this chapter deals primarily with civil telegraphy, it may be well to remark also on some of the early developments of military telegraphy in India and the work of certain military engineers in field telegraphy.

Military telegraphy was first introduced into the Corps of Royal Engineers in 1854, when buried lines were laid and operated in the Crimea by its officers and men; but the difficulties which were experienced in maintaining and working these lines prevented a proper recognition of the value of telegraphic communication in the field, and military telegraphy languished after the close of the war against Russia.[3] Neither in England nor in India were there any military telegraph units when the Indian mutineers seized Delhi and Lucknow in 1857. Patrick Stewart had been reappointed in July, 1856, to officiate for Dr. O'Shaughnessy, and was reconnoitring for a telegraph line in Ceylon when he heard of the outbreak of the Mutiny. Returning at once to Bengal, after leaving instructions at Madras for the commencement of a line towards Calcutta, he spent the next four months in rapid journeys between Calcutta and Allahabad, organizing the telegraph arrangements in the theatre of war and pressing on the construction of the East Coast line. On November

[1] A memoir of Colonel D. G. Robinson, C.B., late Royal (Bengal) Engineers, appears in *The R.E. Journal*, Vol. 7, 1877, pp. 93–94. It is an extract in French from the *Journal Télégraphique*, dated August 25th, 1877.

[2] A memoir of Major John Eckford, R.(B.)E., appears in *The Royal (Bengal) Engineers*, by Colonel Sir E. T. Thackeray, V.C., K.C.B., pp. 258–261, and also in *The R.E. Journal*, November, 1881.

[3] *History of the Corps of Royal Engineers*, by Major-General Whitworth Porter, late R.E., Vol. II, pp. 151–153.

3rd he began to lay a line from Cawnpore towards Lucknow for Sir Colin Campbell's first advance. He brought it into the Alam Bagh, south of the city, before the attack, but it was soon cut by the rebels.[1]

On January 15th, 1858, some time after the rescue of the Residency garrison, Patrick Stewart handed over charge of the civil telegraph system to Dr. O'Shaughnessy, and was then free to devote all his attention to field lines for use in the final assault on Lucknow. He reopened an office at the Alam Bagh on February 19th and extended his line to the Dilkusha on March 6th during Sir Colin Campbell's attack. "Never since its discovery," wrote the correspondent of *The Times*,[2] "has the electric telegraph played so important a *rôle*. It has served the Commander-in-Chief better than his right arm. In this war, for the first time, a telegraph wire has been carried along under fire and through the midst of a hostile country. The telegraph was brought into connection with the Governor-General at Allahabad, with Outram at the Alam Bagh,[3] with Calcutta, Madras, Bombay and the most remote districts. It is mainly to the zeal, energy and ability of a young officer of the Bengal Engineers, Lieutenant Patrick Stewart, that these advantages are due. At one time his men are chased for miles by the enemy's cavalry; at another they are attacked by Sowars, and they and the wires are cut to pieces. Again, their electric batteries are smashed by the fire of a gun, or their cart knocked to pieces by a round shot; but still they work on, creep over arid plains, cross watercourses, span rivers and pierce jungles, till one after another the rude poles raise aloft their slender burden, and the quick needle vibrates with its silent tongue amid the thunder of the artillery. As Sir Colin Campbell advanced towards Lucknow, the line was carried with or soon after him; a tent was pitched near his, a hole was dug in the ground and filled with water, and down dropped the wire from a pole stuck up in haste, dived into the water otter-like, the simple magnet was arranged, the battery set in play, and at once the steel moved, responsive to every touch. The wire is thick and is not protected by non-conductive coatings of any kind; it is twisted round the top of a rude pole, and is found to answer perfectly." Thus India showed the world the value of field telegraphy in war.

But unhappily the experience gained in the Indian Mutiny was put to no useful purpose after the rebellion had been subdued. All energies were devoted to the extension of civil telegraphs and the linking of India with Europe, with the result that military telegraphy suffered an eclipse. There was no engineering staff at Army Headquarters, nor any officer to plead the cause of technical troops.

[1] The operations in the first and second attacks on Lucknow are described in Vol. I, Chapter XVIII, pp. 355–362. Stewart erected a semaphore in the Alam Bagh which signalled to Outram in the beleaguered Lucknow Residency.

[2] Extract from *The Times* quoted in *Telegraph and Travel* by Colonel Sir F. J. Goldsmid, K.C.S.I., C.B. (1874), pp. 45, 46.

[3] For some months after his rescue from the Residency, Outram held the Alam Bagh as an advanced base for the final attack on Lucknow.

Only when wars in Europe had re-emphasized the importance of military telegraphy were measures proposed for the establishment of a "Military Telegraph Train" in India. At the end of 1867, Lieutenant O. B. C. St. John, Royal (Bengal) Engineers, was successfully laying and operating a telegraph line during the Abyssinian campaign, and the Indian Government was then requested to take up the matter of military telegraphy. Accordingly, Colonel D. G. Robinson, the Director-General of Telegraphs, prepared a scheme for a Telegraph Train for India; but unfortunately his proposals met with scant approval and little progress was made. Although companies of Sappers and Miners were employed occasionally on telegraph construction, they were mere adjuncts to civilian labour, or took the place of civilian labour on trans-frontier lines.[1] No advance was made for several years until Lieut.-Colonel (afterwards General Sir Frederick) Maunsell, Royal (Bengal) Engineers, then Commandant of the Bengal Sappers and Miners, organized Field Telegraph Sections for certain Camps of Exercise, and was strongly supported in this venture by Lord Napier of Magdala and Major-General Sir Frederick Roberts. Field lines were worked by these sections at various camps formed between 1871 and 1876.[2] The ability and energy of Captain (now General Sir Bindon) Blood, R.E.,[3] and Lieutenant G. R. R. Savage, R.E.,[4] were of great assistance. A beginning was made in the instruction of British soldiers in civil telegraph offices; but experience in war was denied them, because the operation of field telegraphs in frontier expeditions was still allocated entirely to the Civil Department.[5]

Definite sanction for a military telegraph organization was not accorded until September, 1878, on the eve of the Second Afghan War, when two companies of Bengal Sappers were hurriedly equipped as telegraph units and despatched as soon as possible to the front. One company, under Lieutenant W. F. H. Stafford, R.E., advanced with the Peshawar Force, and the other, under Lieutenant P. Haslett, R.E., with the Kandahar Force. For a long time, the terminus of

[1] In the *History and Digest of Service, 1st K.G.O. Sappers and Miners*, p. 31, the following remarks appear: "9th Company on Telegraph work. June, 1869"; and "6th Company made the Telegraph line from Dera Ismail Khan to Bannu. February to June, 1871."

[2] In 1876, at Delhi, a field telegraph, carried on mules, accompanied troops in the field for the first time. It had 29 officers and men, 13 mules, and 6 miles of light insulated cable. (See *The R.E. Journal*, Vol. 6, 1876, pp. 44–45.)

[3] Then Superintendent of Park, Bengal Sappers and Miners, Roorkee.

[4] Instructor in Telegraphy and Signalling.

[5] Article entitled "Memoranda on the Military Telegraph Train in India," by Major-General F. R. Maunsell, C.B., appearing in *The R.E. Journal*, Vol. 11, 1881, pp. 39–41. "Between 1877 and 1880 the Sappers and Miners were more concerned with heliographic than with telegraphic signalling in the field. Lieutenant (now Colonel) J. C. Campbell, R.E., was the first to bring the heliograph into use in war through the establishment of communication between Peshawar and Shergasha during the Jowaki Expedition of 1877–78. Heliographic signalling was used extensively, during the Second Afghan War, to reinforce telegraphic signalling, one of its keenest exponents being Lieutenant H. Whistler Smith (afterwards Colonel Smith-Rewse) R.E."

the Peshawar line remained at Jalalabad, but in April, 1879, the telegraph was continued to Gandamak. Stafford began to lay his field line directly the troops moved, and brought it into Gandamak with the advanced guard. At one time he was actually ahead of the advanced guard! The Superintendent of the Civil Telegraphs, whose more permanent line followed that of the Sappers, was much impressed by Stafford's speed, but complained that all interest and heart were taken out of his work because it involved no more than the replacement of the Sapper line.[1] He was pestered with suggestions for the protection of his line. Some bright intellect evolved the idea that the wires should be electrified at a high voltage, so that anyone touching them would be electrocuted. Another thought that a submerged cable in the Kabul River would be preferable to an overhead line. An enthusiast in bricks and mortar preferred a cable buried in masonry along the whole length of the route into Afghanistan. A fourth helper disagreed, and advocated posts so tall that no one could get at the line. A fifth advised that the posts and wires should be smeared with pig's fat. It was all very amusing, but it worried the unfortunate Superintendent plodding patiently behind the rapidly-moving Sappers.

Military telegraphy received scant encouragement after the Afghan War, and the Telegraph Sections, which were organized as part of the Sapper and Miner depot companies, had little inducement to keep themselves efficient, though they endeavoured to do so. Their equipment was rarely used in the field, and the *personnel* went on service under the orders of the civil staff of the Telegraph Department.[2] It was considered that the Department provided a sufficiently good telegraph service for a force acting on the frontier. There were practically no mobile telegraphs of any sort, because their utility was not understood. Although Colonel Bindon Blood, when Commandant of the Bengal Sappers in 1887, reorganized the Roorkee Telegraph Sections[3] with the help of Lieutenant (afterwards Major-General Sir Francis) Bond, R.E., orders came in January, 1890, that all telegraphic equipment, other than instructional equipment, was to be handed over to the Telegraph Department, which would make every arrangement in future for the supply of telegraphs in the field.[4] Royal Engineer officers, and British soldiers of all arms, were to be attached annually to the Department for training in telegraphy; and before this system was abolished in 1907, no less

[1] *Administration Report of the Indian Telegraph Department for* 1788–79, Appendix M.

[2] Article entitled "The Telegraph Section, 1st Sappers and Miners, at the Meerut Divisional Manœuvres, February, 1905," by Captain B. W. Mainprise, R.E., appearing in *The R.E. Journal*, Vol. II, July–December, 1905, pp. 296–298.

[3] A general reorganization of the three Corps of Sappers and Miners was authorized under Indian Army Circular No. 174, dated December 16th, 1885. (See Vol. I, p. 393.)

[4] However, in the Third China War in 1900, military telegraph sections erected and maintained many semi-permanent lines without civil assistance.

than 24 officers and many hundreds of other ranks had received from 18 months' to 2 years' instruction.

The evolution of the Indian Signal Corps from the Sapper and Miner Telegraph Sections is outside the scope of this narrative. At the outbreak of the Great War in 1914, the Signal Corps did not exist but was represented by four Divisional Signal Companies and a Wireless Section, affiliated to the Sappers and Miners and officered and manned from all arms of the British Service and Indian Army.[1] Military telegraphy had ceased to be the Engineer's preserve, and its history calls for no further remark. We turn accordingly to the story of the connection of India with England by electric telegraph—the most outstanding telegraphic achievement in which military engineers have ever been concerned, and one which brought out those qualities of patience, enterprise and hardihood which have enabled Englishmen to hold and govern their Eastern possessions.

After the first Atlantic cable had been laid, and the feasibility of submarine telegraphy fully demonstrated, electrical ingenuity was directed to this project. Those who were interested in the welfare of India had recognized, shortly before the Indian Mutiny, that a boon would be conferred on both England and India if they could be brought into closer communion through the time-annihilating medium of electric wires.[2] Alexandria was already in telegraphic touch with London, and a firm of contractors undertook to continue the submarine system from Suez to Aden and Karachi under a guarantee of a subsidy of £36,000 for 50 years.[3] The cable was laid, during 1859, in six sections from Suez, through Kosseir and Suakin, to Aden, and thence through Hallain and Muscat, on the Arabian Coast, to Karachi.[4] Numerous faults appeared ; not a single message was ever passed over the whole length of the line ; and the project ended in a disastrous and costly failure which disheartened both the Home and Indian Governments.

Public attention was naturally diverted from telegraphs during the Indian Mutiny ; but afterwards, the Government of India, seeing that submarine telegraphy was making good progress elsewhere, determined once again to obtain the desired connection between India and England, though by another route. As Turkey was plan-

[1] A Wireless Section, under Captain D. A. Thomson, R.E., had been formed at Roorkee in October, 1909. In November, 1910, the Telegraph Sections of all three Corps of Sappers and Miners were absorbed into four Divisional Signal Companies, and the Wireless Section was transferred to " Signals." (Indian Army Department Circular No. 188/1/A.G.3, dated 16.11.1910.)

[2] The postal arrangements were very defective. Until 1867, two years before the opening of the Suez Canal, letters could only be sent once a month and were about 26 days in transit.

[3] *History of the Corps of Royal Engineers*, by Major-General W. Porter, late R.E., Vol. II, p. 337. A brief account of the Indo-European Telegraph Construction appears in that volume on pp. 337–340.

[4] " Telegraph Routes between England and India," appearing in *The R.E. Journal*, Vol. 8, 1878, p. 62. The article is continued on pp. 70, 81 and 95, and is a valuable contribution to the history of the Indo-European telegraphs.

ning a line of telegraph from Constantinople to Baghdad, it was proposed that this line should be continued thence to India by the British Government ; and in view of the failure in the Red Sea, this scheme was gladly adopted.[1] It provided for a land line along the Mekran Coast from Karachi to a point as far west as practicable, and thence a submarine cable to the head of the Persian Gulf, where the cable was to join an extension of the Turkish line from Constantinople through Baghdad. A loop line through Persia, running northwards from Bushire (the selected western point) to Teheran, and thence south-westwards to Baghdad, was afterwards included as a possible alternative to the extension line from Baghdad direct to the Gulf, because it was feared that the feeble control exercised by Turkey over the Arab tribes south of Baghdad, and the malarious climate of the Shatt-al-Arab region, would present serious obstacles to construction and operation.

Many diplomatic difficulties had to be surmounted before a convention could be concluded with Turkey for the land line from Constantinople to Baghdad ; but the line was completed by the Turks in 1861, and, in the following spring, Lieut.-Colonel Patrick Stewart, R.(B.)E., accompanied by Lieutenant J. U. Champain, R.(B.)E.,[2] left Karachi for Bushire to prospect for the loop line through Persia. They marched to Teheran and there separated, Stewart proceeding to England to superintend the manufacture and supply of materials, and Champain reconnoitring the country from Teheran to Baghdad. The line was to be laid by the British between Baghdad and Khanikin, beyond the Persian frontier, and thence through Persia to Teheran to link with a line from Bushire to Teheran, while a submarine cable would be laid from Bushire to Fao at the head of the Persian Gulf below Basra. The land line from Fao to Baghdad was also to be laid by the British. Such was the general idea.

After a year had been spent in fruitless negotiations with the Persian Government, a convention was at length concluded by which the Persians themselves undertook to erect the desired loop line from Baghdad through Teheran to Bushire, and to allow one British officer to advise them. Champain was selected for this task, but he did not go alone. Instead, he took with him a small staff, including Lieutenants R. Murdoch Smith, R.E., O. B. C. St. John, R.(B.)E., and W. H. Pierson, R.(B.)E., all of whom figure later in this narrative.[3] He had also the advantage of the services of 12 N.C.O's of the Royal Engineers. A line about 1,250 miles in length, through an extremely difficult country, had to be made with Persian materials and at Persian expense by a handful of foreigners whom

[1] *A History of Persia*, by Brig.-General Sir Percy Sykes, K.C.I.E., C.B., C.M.G., Vol. II, p. 367 (3rd Edition, 1930).

[2] Afterwards Colonel Sir John Bateman-Champain, K.C.M.G. Champain assumed the additional name of Bateman in April, 1871.

[3] Champain was assisted also by two civil engineers, Messrs. H. Man and H. V. Walton.

every man in the kingdom, from the Shah downwards, then regarded as pestilential interlopers. Work began in the autumn of 1863, and the line from Teheran to Bushire was nearly completed when matters came to a deadlock. A certain party of Persians offered the most persistent obstruction. For two or three months Champain and his men withdrew altogether from the work, and it seemed likely that they would leave Persia. However, an official known as the "Telegraph Prince," having at first reluctantly consented that the British should remain for five more months, became ultimately so horrified by the idea of their departure, which would have involved the complete breakdown of the scheme, that he withdrew all his objections and the Teheran–Bushire line was finished on October, 13th, 1864, when Teheran was also linked with Baghdad. In the following February, Lieut.-Colonel (afterwards Sir Arnold) Kemball, Bombay Artillery, connected Baghdad with Fao.

It was from no special desire to bring Persia into telegraphic touch with Europe, nor with any direct intention of conferring upon her the benefits of telegraphy, that a line was taken through the Shah's dominions. Her geographical position was the determining factor. Had Persia not lain between Great Britain and India she might have waited long for the outside pressure necessary to effect so startling a change. In 1863 her people were in what Mr. Edwin Montagu would have termed a state of pathetic contentment as regards modern innovations. The oppressions and extortions of their officials, and the hardships of their existence, they took as a matter of course. Thier motto might have been "*Farda Insha-Allah*" (to-morrow, if God will) which is still the usual Persian reply to the question "When?" The country was Eastern to the core. A British official was required to observe the most punctilious formalities in calling on a Persian dignitary. On such occasions each alluded to himself as a humble slave, and to the other as "Your Excellency." "How is the health of your August Highness?" "Thanks be to God, by the kindness of Your Excellency, this slave's health is good." And so on for ten minutes before even a hint could be given as to the real purpose of the visit. Through the midst of such a people Champain thrust his electric wire.

The Indo-European Telegraph Department was at work on a connection between Persia and India before Champain began to build the loop line through Persia. A land line was begun along the Mekran Coast from Karachi in June, 1862, and reached Gwadur in April, 1863. Mr. H. V. Walton and his men had an unenviable task. Sir Thomas Holdich describes Mekran as a dead monotony of laminated clay backbones, serrated like whales' vertebræ, projecting from the smoother outlines of mud ridges which slope down to drainage lines marked by sticky salt.[1] The people of this desolate

[1] *The Indian Borderland*, by Colonel Sir T. H. Holdich, K.C.M.G., K.C.I.E., C.B., late R.E., p. 319.

region have some peculiar customs. Many years ago, Major (now Sir Percy) Sykes noticed that almost every camel had more than one owner. Occasionally four men each owned a leg; but the usual arrangement was for the owner to retain three legs and to give the driver the fourth in lieu of wages.[1]

The first submarine cable from Karachi through Gwadur to Jask, and thence to Bushire and Fao, was laid by Lieut.-Colonel Patrick Stewart from sailing vessels towed by steamers.[2] Laying began in February, 1864, and within three months Fao was in telegraphic touch with Karachi; but owing to the fact that the Fao–Baghdad line had not been completed, there was no through communication with Europe by way of Mesopotamia and Anatolia until January 27th, 1865.[3] Although the construction of a portion of the loop line from Baghdad through Khanikin to Teheran had then been finished, the line was subject to constant interruption of communication, and it was not until April, 1865, that messages could go with any certainty by the Persian route.

Fate decreed that Lieut.-Colonel Patrick Stewart, the pioneer of Persian telegraphs, should not live to see regular telegraphic communication established between India and England. He had been in Constantinople since July, 1864, suffering seriously in health, but vigorous as ever in his efforts to induce the Ottoman authorities to improve the operation of their part of the route. In December, he became very ill. The strain had been too great. He succumbed on January 16th, 1865, at the early age of 32 years, and was buried in the beautiful English cemetery at Scutari alongside the heroes of the Crimea. His meteoric career was thus brought to an untimely end on the very eve of the completion of the arduous task which he had undertaken.

The post of Director-in-Chief of the Indo-European Telegraph Department having fallen vacant through Stewart's death, Lieut.-Colonel F. J. Goldsmid, C.B., of the Madras Infantry,[4] was appointed to it. Champain was then withdrawn from Persia to become Goldsmid's assistant. For some years, their efforts were concentrated in Turkey, where Champain spent the greater part of 1866 in trying to get the Constantinople–Baghdad line into a state of efficiency. In 1867 he was sent to St. Petersburg to carry on some difficult negotiations. The Russians had extended their telegraph system to the Persian frontier to make connection with a rickety line which the Persians had built through Tabriz to Teheran, and a telegraph

[1] *Ten Thousand Miles in Persia*, by Major P. M. Sykes, p. 109.

[2] This gutta-percha cable weighed about four tons per mile, and cost about £200 per mile.

[3] *Report on the Indo-European Telegraph Department*, 1863–1868, by Colonel H. A. Mallock, Bengal Staff Corps, Director-General of Telegraphs, Calcutta, 1890.

[4] Afterwards Major-General Sir Frederick Goldsmid, K.C.S.I., C.B., the author of *Telegraph and Travel* (1874) and *James Outram. A Biography* (1880). He was engaged on several Boundary Commissions in Persia and elsewhere, and served in Egypt from 1880 to 1883.

convention had been concluded between Russia and Persia. The new route between Europe and the East was extensively advertised, but it failed under a sudden rush of messages. Before Champain went to Russia he had received an offer from Messrs. Siemen and Co. to build a double line from London to Teheran, and his visit to the Tsar's capital was largely in this connection. Although he secured no definite agreement from the Russian Government, he established cordial relations with the Russian Director-General of Telegraphs which paved the way for the concession subsequently granted to a British concern called the Indo-European Telegraph Company. This concession provided for the erection of a line through Russia to connect London with Teheran, thus avoiding the Turkish system and completing a chain of direct and special communication between England and India. The new route through Germany and Russia was opened on January 31st, 1870, and it owed much of its success to Champain's diplomacy.[1] The Persian section from the Russian frontier to Teheran had been made afresh ; and two wires, specially devoted to Indian traffic, were available over the whole distance from London to Teheran. From Teheran, through Bushire, to Karachi, the traffic was under the direct control of the Indo-European Telegraph Department.

The difficulties encountered in the construction of the original loop line through Persia are exemplified by the experiences of Lieutenant R. Murdoch Smith, R.E., who landed at Bushire on November 17th, 1863, with 12 N.C.O's of the Royal Engineers and a mass of telegraphic stores, and travelled to Teheran with Champain. The line between Baghdad and Bushire was divided by Champain into five sections: Baghdad to Kangawar, under Lieutenant W. H. Pierson, R.(B.)E. ; Kangawar to Teheran, under Mr. H. V. Walton ; Teheran to Kohrud, under Lieutenant R. Murdoch Smith, R.E. ; Kohrud to Murghab, under Mr. H. Man ;[2] and Murghab to Bushire, under Lieutenant O. B. C. St. John, R.(B.)E. Leaving Teheran on February 26th, 1864, Murdoch Smith soon reached his headquarters at the holy city of Kum, the burial place of Fatima, to begin work on his section, 200 miles in length. He found that neither wire, insulators nor tools had been sent from Ispahan by the Persians. In March he received the wire and insulators, but no tools ; and when at last he had got his tools and applied to the Persian officials for workmen, he was given a few old men and boys. These were followed by 30 labourers, but the latter decamped because they had received no pay. Murdoch Smith, having tried unsuccessfully to obtain some money from the Governor of Kum, appealed to Teheran and in the end was given about three dozen labourers, half of

[1] The Russian route quickly took the lead. In 1872, when a message between England and India usually took 30 hours to get through by the Turkish route, it took only six hours by the Russian route.

[2] Mr. Man was soon invalided and was succeeded by Mr. Hoeltzer.

whom, for want of mules, had always to be employed in carrying poles.

Murdoch Smith was a rigid disciplinarian and abhorred the corrupt dealings of the Persian officials and contractors. "I found," he writes, "that all were actuated by the same principles. When they thought it possible to make *mudakhil* (perquisites) they were all activity; but when their income was interfered with by the system I adopted of seeing everything paid in my presence, and warning the villagers on no account to give 'presents' to anyone, they relapsed into their usual state of obstinate indifference." Nevertheless he completed his section during the autumn of 1864; and when Champain left Teheran in the following year, Murdoch Smith took his place as Director in Persia. In 1866 his staff was increased by the arrival of Lieutenant (afterwards Major-General) B. Lovett, R.(B.)E., who joined as an assistant to St. John and worked on the Persian telegraphs for four years,[1] but even so it was difficult to cope with the maintenance and improvement of the lines. "Much of our time between 1864 and 1870," writes Murdoch Smith in 1883,[2] "was taken up in special employments, such as Captain St. John's service with the Army in Abyssinia and with the Eastern Persia Frontier Commission; Captain Pierson's detachment on special duty to Mazanderan, to the Caucasus, to Vienna for the International Telegraph Conference, to Bombay, to London, and finally to Teheran to superintend the erection of the new British Legation; Lieutenant Lovett's service with the squadron on the Arabian Coast and on the Frontier Commission; and my own absence on special duty in Baluchistan, Arabia and India. During this period, however, every opportunity of exploring and surveying the country was eagerly seized. To the skill and perseverance of Captain St. John we are indebted for the admirable map which must form the groundwork of all future surveys of Persia. From 1871 to 1873 Captain Pierson was the only officer in Persia, and I was the only one from his departure in 1873 until the arrival of Captain H. L. Wells, R.E., in the beginning of 1881."

The success of the Indo-European telegraph system in Persia was due, in a great measure, to the unremitting labours of Murdoch Smith. By his tact, good temper, courage, perseverance and remarkable linguistic powers,[3] he converted hostile opposition into friendly feeling. He earned the confidence and respect of Persians of every degree; and when, in 1885, after more than 20 years in Persia, he accepted the directorship of the Science and Art Museum at Edinburgh, he was presented with a sword of honour by H.I.M. the

[1] A memoir of Major-General Beresford Lovett, C.B., C.S.I., late Royal (Bengal) Engineers, appears in *The R.E. Journal*, Vol. XLI, March–December, 1927, p. 155.

[2] Letter from Lieut.-Colonel R. Murdoch Smith, R.E., quoted in *The R.E. Journal*, Vol. 13, 1883, p. 108.

[3] Murdoch Smith spoke Persian fluently, and could converse in French, German, Italian, Spanish, Turkish and Arabic. He was also an accomplished musician.

Shah prior to his departure from the country. He conducted the difficult negotiations connected with the acquisition of a site for the British Legation at Teheran, enclosed the grounds, and provided the water-supply, and in his spare time amassed a splendid collection of tiles, carpets and other objects of Persian art, which was afterwards sent to South Kensington.[1] In 1887 he became Director-in-Chief in London of the Indo-European Telegraph Department in succession to Colonel Bateman-Champain, who died on February 1st of that year. Afterwards, he re-visited Persia, where he accomplished some valuable political work, and in 1888 he was gazetted a K.C.M.G. Major-General Sir Robert Murdoch Smith died on July 3rd, 1900, after a life of chivalrous devotion to duty and unswerving loyalty to his comrades and friends.[2]

There was little sweet water in the country between Bushire and Teheran, through which Murdoch Smith, Man and St. John built their sections of the Persian loop, and bushes and trees were scarce. When snow was on the ground a traveller could get nothing better than dried thorns for fuel, and could hope for no better shelter than a damp and dirty *caravanserai*. Working parties on the passes often laboured up to their hips in snow, and took refuge in a cave for the night. The wives and children of the British telegraph employees, who followed their husbands and fathers into the wilds when the line was finished, travelled on horseback or rode, as the Persian women did, in *kajawahs* or panniers slung on each side of a mule, or in palanquins carried between two mules. Wheeled conveyances were almost unknown, for the roads were execrable. Robbers lay in wait for unguarded travellers. Corporal Collins, late R.E., was attacked and killed after accounting for three of his assailants. Three others of the gang were caught by the Persian Governor, who buried them up to their waists and then built gypsum around them up to their necks so that they suffocated slowly as the gypsum solidified.

Dangers from wild beasts had also to be reckoned with. In March, 1867, St. John was riding from Shiraz to Mian Kotal and had just entered an oak forest when a lioness emerged some 30 yards in front of him. His horse stopped; so did the lioness; and for a few seconds they stood looking at each other. Then St. John cracked his whip and shouted; but instead of sneaking back into the forest as he expected, the lioness charged and sprang at the horse's throat. She missed her spring, and came down under St. John's stirrup. Having no weapon except a small revolver, he tried to spur his horse

[1] Murdoch Smith was already well known as an archæologist through his discoveries of Greek antiquities in Asia Minor during 1856–58, and near Tripoli in 1860–61. The results are in the British Museum. (See *History of the Corps of Royal Engineers*, by Major-General W. Porter, Vol. II, pp. 363–67.)

[2] A memoir of Major-General Sir Robert Murdoch Smith, K.C.M.G., late R.E., appears in *The R.E. Journal*, Vol. 30, 1900, pp. 192–194. A full account of his career is given in *The Life of Major-General Sir Robert Murdoch Smith, K.C.M.G., late R.E.*, by W. K. Dickson (1901).

forward, but the animal refused to move, and in another moment the lioness had sprung on to its hindquarters. St. John jumped off. The horse plunged violently, knocking him in one direction and throwing the lioness in another, and then, trotting away, was overtaken by the lioness who sprang on to its hindquarters once more and both thus vanished into the forest. After a time, St. John followed, only to discover that although the lioness had vanished, the horse was so frantic with terror that it could not be approached, so he left it till next morning, when he found it badly mauled but grazing quietly. Its wounds were sewn up, and within a week it was as well as ever.[1]

Many instances of bravery and devotion to duty are recorded in the history of the Persian telegraphs. When Corporal Blackman, late R.E., a Telegraph Inspector, arrived one winter's afternoon at Dehbid, he learnt that his servant had been bitten by a mad wolf. This beast, after biting many other people, all of whom are reported to have died, next seized a man in a dark passage leading into the telegraph station; whereupon Blackman ran out, felt for the heart of the brute, and shot it dead with his revolver.[2] The women were not behind the men in courage. From February 24th to March 30th, 1891, Mrs. Smith, the wife of an Inspector at distant Siwand, having learnt, as many women did, to receive and send messages, kept the telegraph office open and worked it alone while nursing her husband, who was ill with enteric fever. England has reason to be proud of the men and women who forged and held the Persian link of the telegraphic chain to India.

As soon as the proposal of Messrs. Siemen and Co. to build a double line of telegraph through Russia and Germany had assumed a definite aspect, the attention of Government was directed to the development of the Persian Gulf and Mekran Coast lines. A single submarine wire from Bushire, through Jask, to Gwadur being palpably insufficient, it was decided that the Mekran Coast line should be extended from Gwadur to Jask, and that a second submarine cable should be laid from Jask to Bushire. A third wire was to be attached to the Bushire–Teheran land line, so that one wire might be reserved for local traffic and the other two devoted entirely to international business. The extension by land from Gwadur to Jask was completed in August, 1869, and the new cable from Jask to Bushire in November.[3] Champain came from England to supervise the latter undertaking, and nearly lost his life on the voyage to India, when the P. and O. s.s. *Carnatic* was wrecked in the Gulf of Suez.[4] The

[1] *Life of Major-General Sir Robert Murdoch Smith, K.C.M.G., late R.E.*, by W. K. Dickson, pp. 263–264.

[2] *Ten Thousand Miles in Persia*, by Major P. M. Sykes, p. 330.

[3] This was an india-rubber covered cable instead of a gutta-percha cable as used for the original line.

[4] *History of the Corps of Royal Engineers*, by Major-General W. Porter, Vol. II, p. 532; and Obituary Notice of Colonel Sir John Bateman-Champain, K.C.M.G., late R.E., appearing in *The R.E. Journal*, Vol. 17, 1887, pp. 56–60. A full account of the shipwreck appears in the latter publication.

Persian Gulf and Mekran Coast lines, when thus duplicated, were able to cope with the flood of messages let loose upon them in 1870 through the Indo-European Company's system in Europe and Northern Persia and the line from Teheran to Bushire.

Jask, the new western terminus of the Mekran Coast line, was a depressing spot. According to General Macgregor,[1] no human ingenuity could make it an acceptable residence for an ordinary mortal. "The only materials for a landscape," he writes, "are glaring, glittering, glabrous sea for a foreground; a glaring, shiny, sandy plain for the mid-distance; and bare volcanic hills for the background. Add to this, heat which must make a nervous sinner most apprehensive, and the fact that you never see a soul from the outside world, and only get letters twice a month." The chief difficulty at all stations, except Chahbar, was water-supply. At a few feet below ground-level, a kind of crust existed above which pure water collected and could be tapped in small quantities; but if the crust was perforated, brackish water was encountered, and the well, and all adjacent wells, were ruined for ever. At Gwadur the supply was so bad that all drinking-water had to be condensed from the sea.

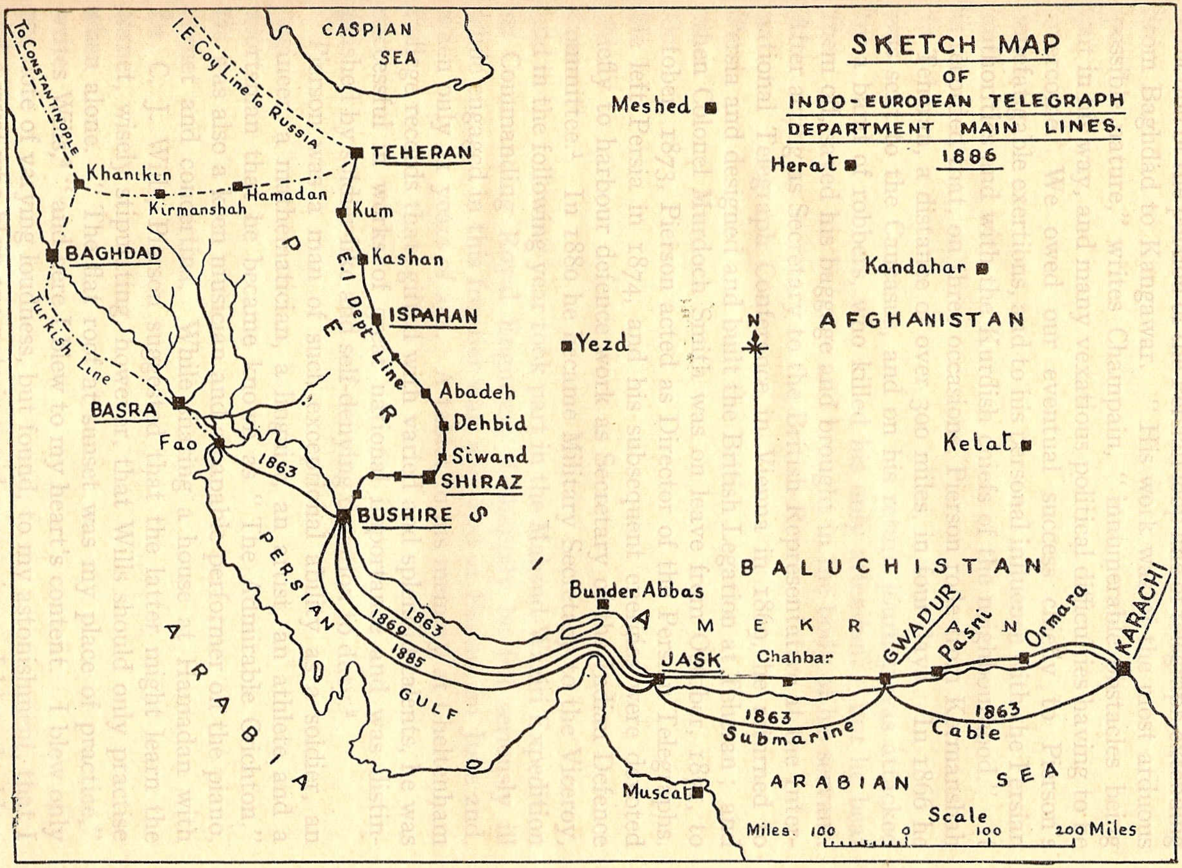
The opening, in January, 1870, of the telegraphic route between England and India by way of Germany, Russia, Persia and Mekran was followed immediately by a second attempt to lay a submarine cable between Suez and Bombay. The British-Indian Submarine Telegraph Company employed five ships on this undertaking, including the mammoth *Great Eastern* of Atlantic fame, and was so successful that a cable was laid over the whole distance between February 7th and March 22nd. On March 26th, 1870, a British-Indian telegraph route was opened to the public *via* Suez, Alexandria, Malta, Marseilles and Paris; and when a cable was laid in June from Malta through Gibraltar to Falmouth, a connection was established which was entirely British.[2] The submarine route provided a valuable alternative to the Persian route, which suffered from frequent minor interruptions, although breaks in the submarine cables sometimes caused serious dislocation of traffic.[3] Competition with the submarine system was an incentive to renewed efforts on the part of the Indo-European Telegraph Department and Company which resulted in greater efficiency in their overland systems. Transmission was accelerated, and charges for messages were reduced.

At this period, Captain William Henry Pierson, R.(B.)E., had

[1] *Wanderings in Baluchistan*, by Major-General Sir C. M. Macgregor (1882).

[2] "Telegraph Routes between England and India," appearing in *The R.E. Journal*, Vol. 8, 1878, pp. 81–82.

[3] In 1870–71 the Red Sea cable was paralyzed for 15 days, and the Lisbon–Gibraltar cable for 72 days. In 1874–75 the connection between Falmouth and Gibraltar was broken for 33 days; and in 1875–76, the Red Sea cable was interrupted for 80 days. Accordingly, the Suez–Bombay cable was duplicated between October, 1876, and March, 1877.



SKETCH MAP OF INDO-EUROPEAN TELEGRAPH DEPARTMENT MAIN LINES, 1886.

established an excellent reputation in Persia. It will be remembered that he had accompanied Major Patrick Stewart to that country in 1863, and was placed by Captain Champain in charge of the construction of the portion of the Persian loop line of telegraph extending from Baghdad to Kangawar. " His work was of the most arduous possible nature," writes Champain, " innumerable obstacles being put in his way, and many vexatious political difficulties having to be overcome. We owed our eventual success chiefly to Pierson's indefatigable exertions, and to his personal influence with the Persian authorities and with the Kurdish chiefs of the neighbourhood." It is recorded that, on three occasions, Pierson rode from Kermanshah to Teheran, a distance of over 300 miles, in four days. In 1866 he was sent to the Caucasus, and on his return journey was attacked by a band of robbers, who killed his only attendant ; but he beat them off, saved his baggage and brought in the body of his servant. After acting as Secretary to the British Representative at the International Telegraph Conference in Vienna in 1869, he returned to Persia and designed and built the British Legation at Teheran ; and when Colonel Murdoch Smith was on leave from October, 1871, to October, 1873, Pierson acted as Director of the Persian Telegraphs. He left Persia in 1874, and his subsequent energies were devoted chiefly to harbour defence work as Secretary of the Indian Defence Committee.[1] In 1880 he became Military Secretary to the Viceroy, and in the following year took part in the Mahsud-Waziri Expedition as Commanding Royal Engineer. Unhappily he fell seriously ill while engaged in this frontier war, and died at Bannu, on June 2nd, when only 41 years of age. A tablet to his memory at Cheltenham College records that, gifted with varied and splendid talents, he was successful in works of great national importance and was distinguished by soldier-like and self-denying devotion to duty.[2]

Pierson was a man of such exceptional ability as a soldier, an engineer, a mathematician, a linguist, an artist, an athlete and a sportsman that he became known as " The Admirable Crichton." He was also a keen musician and a capable performer on the piano, cornet and concertina. While sharing a house at Hamadan with Dr. C. J. Wills, Pierson suggested that the latter might learn the cornet, wisely stipulating, however, that Wills should only practise when alone. " The flat roof at sunset was my place of practice," writes Wills,[3] " and here I blew to my heart's content. I blew only one note of varying loudness, but found, to my astonishment, that I had a rival who blew one note in rapid succession. I blew, he blew

[1] See Chapter X., p. 173.

[2] Memoirs of Major W. H. Pierson, Royal (Bengal) Engineers, appear in *The R.E. Journal*, Vol. 11, 1881, pp. 165–166 ; in the *History of the Corps of Royal Engineers*, by Major-General W. Porter, Vol. II, pp. 535–536 ; in *Addiscombe. Its Heroes and Men of Note*, by Colonel H. M. Vibart, pp. 643–646 ; and in *The Royal (Bengal) Engineers*, by Colonel Sir E. T. Thackeray, V.C., K.C.B., pp. 232–235.

[3] *Land of the Lion and Sun*, by Dr. C. J. Wills (1883), pp. 71–72.

—but his were the stronger sounds. The next night, my rival was absent. I blew one note in rapid succession. Suddenly I heard cries, sounds of beating, and shouts of men and women—but I blew on. In the morning a complaint was made to Pierson. It appears that, when the public bath is full of men, and the time expires, the bath is cleared and the bath-man then blows a succession of notes on a buffalo horn. This is the signal for the expectant women, and so on, when their time expires, for the men. The day before, the bath being full of women, my efforts on the cornet were so like the bath-man's solos that the Hamadan men rushed in. The women called in their male relatives for protection, and a fight ensued which only ceased on both parties uniting to thrash the innocent bath-man. A small present afterwards consoled the bath-man, and I gave up the cornet."

Much trouble was experienced in maintaining the telegraph lines in Southern Persia. The inhabitants seemed to consider every telegraph pole as a suitable target for rifle practice. Until 1869 the wires were supported on wooden poles, which made useful marks for any youngster who wished to display his skill or to test the penetration of a bullet, and the substitution of wrought-iron poles did not stop the practice altogether. The iron poles were made in three pieces—a footplate (underground), a holder or socket of cast-iron, and a standard of wrought-iron. When the marksmen found that their bullets were inclined to glance off the wrought-iron standards, they shifted their aim to the cast-iron sockets and so brought down the line. Finally the British introduced a special wrought-iron pole consisting of a spiral, like a paper-spill, through which a bullet could pass freely without causing much damage,[1] and this seems to have acted as a deterrent.

The British telegraph offices in Persia were usually considered as sanctuaries by the law-abiding population because the wires were supposed to end " at the foot of the throne," or, in other words, because they were imagined to have direct access to H.I.M. the Shah at Teheran. The offices, however, were not immune from the attacks of rioters or brigands who recognized no authority, and it is said that these attacks were sometimes the result of a rumour that the telegraph instruments were of pure gold—a tribute to the care with which they were polished. The British operators helped in the administration of the country by keeping the Shah informed of the doings or misdoings of the local Governors, and by transmitting his orders to them. Messages from the Governors were also sent to Teheran. Sometimes the local Persian magnates found the telegraph useful in other ways, as when one of them was discovered breaking a massive loaf of sugar with a porcelain telegraph insulator, remarking as he struck, " See what wonderful material. I *always* use it ! "

[1] *Land of the Lion and the Sun*, by Dr. C. J. Wills, p. 301.

During the years which followed the extension of the Mekran line to Jask, the duplication of the submarine cable from Jask to Bushire, and the addition of a third wire to the line between Bushire and Teheran, the Indo-European telegraph system thrived under the control of Lieut.-Colonel Bateman-Champain as Director-in-Chief in London[1] and Lieut.-Colonel Murdoch Smith as Director in Persia. Political and administrative troubles were numerous, but all were overcome by tact and firmness. In the beginning of 1881, Lieutenant Henry Lake Wells, R.E., arrived from India. Wells was a man of great courage who had distinguished himself, while roadmaking during the Second Afghan War, in a hand-to-hand fight with robbers in the Khojak Pass.[2] He had had previous experience in telegraphic work, having been employed from August, 1879, to February, 1880, in surveying and reporting on routes for a proposed line from Srinagar, in Kashmir, to Gilgit. A rigid disciplinarian and quick-tempered, he was often at variance with the Persian officials; but one and all had implicit trust and confidence in his ability and integrity. He explored the country thoroughly and got to know its people. Having been nominated to act as Director of the Persian Telegraphs when Murdoch Smith departed in 1885, he was confirmed in the post in 1891, when Captain H. F. Chesney, R.E., was appointed Assistant Director under his orders.[3] Wells received a sword of honour from the Shah, and remained as Director of the Persian Telegraphs until his death from enteric fever at Karachi on August 31st, 1898.[4]

A few extracts from Wells' reports will serve to show the responsibilities and difficulties of the telegraph administration in Persia. On August 15th, 1882, he writes:[5] "We are very busy on our telegraph lines. Ever since Arabi cut the wires on July 11th,[6] we have had to face the whole of the traffic between England and the East, including China, Japan, the Philippine Islands, Australia and New Zealand. Messages from Suez to Alexandria pass this way, coming *via* Aden and Bombay, and all news from the Cape comes through Aden. Not a single hitch has occurred, though there was a danger last week of our wires being cut by the riotous citizens of Kashan. Our office was invaded for several days by the rioters." On January 25th, 1886, he writes from Teheran:[7] "We have had some exciting times. The people of Mashad rose against the

[1] Lieut.-Colonel J. U. (Bateman) Champain, R.(B.)E., became Director-in-Chief in 1870 on the resignation of Colonel F. J. Goldsmid, C.B., Madras Infantry, who was appointed as arbitrator for the settlement of the eastern frontiers of Persia.

[2] See Vol. I, Chapter XIX, p. 382 and footnote.

[3] Captain H. F. Chesney, R.E., held this post until 1895, when he left Persia.

[4] A memoir of Lieut.-Colonel H. L. Wells, C.I.E., R.E., appears in *The R.E. Journal*, Vol. 28, 1898, pp. 251, 252.

[5] *The R.E. Journal*, Vol. 12, 1882, p. 224.

[6] During the Egyptian Campaign.

[7] *The R.E. Journal*, Vol. 16, 1886, p. 53.

Governor of the city, headed by the priests, whom the Governor had enraged. They besieged the telegraph office and demanded that a message should be sent to the Shah. Their message reached Teheran; but before a reply could be sent, as usual, down went the line. The people, getting no reply, were furious. They wrecked the office and destroyed the lines for some distance. Luckily, the clerks escaped into a harem and were saved. At length the rioters ran short of stones. It came on to rain and sleet, and so the mob dispersed. . . . James Hamilton, ex-Serjeant, R.E., a signaller in the Persian Section, died in the semi-ruined post house at Murghab, north of Shiraz, on January 14th, from the terrible hardships he had experienced in repairing the telegraph lines, which an unusually heavy fall of snow, accompanied by high winds, had damaged over a distance of 120 miles. His telegraph office at Dehbid is at an altitude of 7,000 feet. He was always chosen for this post on account of his great courage, hardihood and determination. Never a winter passed without his having to go out in snow and bitter cold for from three to six days at a time, often threatened by the fate which has now, alas, overtaken him. He leaves a widow and three children." Persia owes much to the discipline and self-sacrifice shown by the handful of non-commissioned officers of the Royal Engineers who formed the backbone of the subordinate Telegraph Staff.

It was discovered in 1884 that the original gutta-percha submarine cable between Jask and Bushire, and the india-rubber cable which was laid in 1869, were becoming unreliable. In 1883 both cables were broken at the same time for a period of 19 days. Consequently Sir Henry Mance, C.I.E., the Engineer and Electrician for the Persian Gulf cables, proposed that a new gutta-percha cable should be laid between these places at a cost not exceeding £88,000.[1] The project was sanctioned in April, 1885, and the cable was laid during November of that year under the personal supervision of Colonel Bateman-Champain, who had come from England for that purpose. This was Bateman-Champain's last visit to the East. On the completion of the work he proceeded to Calcutta to confer with the Government on telegraphic matters, and afterwards went to Delhi to visit his old friend, General Sir Frederick Roberts. While at Delhi he learnt that his services had been recognized by the award of the K.C.M.G., and this, following on the bestowal of a sword of honour by the Shah, made his visit to India a memorable one for him. Unfortunately, he had long been subject to asthma, complicated at times by bronchitis. He was frequently urged to take some months of complete rest in a more genial climate than that of England, but always refused to do

[1] *Official Report of the Persian Gulf Bushire–Jask Cable Expedition*, 1885, compiled under instructions from Colonel Sir John U. Bateman-Champain, K.C.M.G., late R.(B.)E., Director-in-Chief, Government Indo-European Telegraph Department, by Sir Henry C. Mance, C.I.E. The actual cost of the work amounted to about £76,000.

COLONEL SIR JOHN U. BATEMAN-CHAMPAIN, K.C.M.G.,
LATE ROYAL (BENGAL) ENGINEERS.

so; and when at last he was compelled to yield, it was too late. He journeyed from England to the South of France in January, 1887, and died at San Remo on February 1st. Bateman-Champain was respected by all who met him, and loved by all who knew him. His loss was deeply mourned, not only by his countrymen but by Persians of all degrees, in whose hearts, as they affirmed in their picturesque language, his place would ever remain empty.[1]

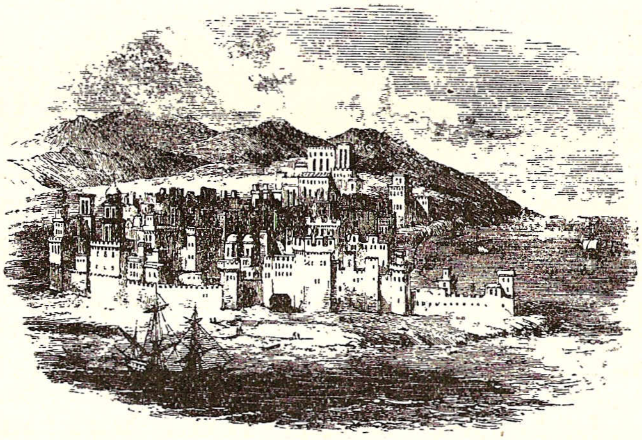
The last connection of the Corps of Royal Engineers with the Indo-European telegraphs was severed with the death of Lieut.-Colonel Henry Wells in 1898. Government decided, during that year, to construct a direct land line across South-Eastern Persia to Karachi, and Mr. King Wood was instructed to make a survey for it. This officer subsequently built the Central Persia Telegraph Line, as it was called, as far as the Indian frontier.[2] The Persian officials were friendly, but the natural obstacles were formidable. Since then the Persian telegraph system has expanded and prospered. Persia, formerly an isolated kingdom, has entered the comity of nations. Her prestige has been enhanced: her people have been imbued with ideas of progress and reform. The telegraph has been largely responsible for this metamorphosis.

The Indo-European Telegraph Department, and its sister company, have ceased to exist. A few years ago, they relinquished all their telegraph lines in Persia. Their record is a noble one. During the Great War the services of their officials were invaluable. These intrepid men furnished Brig.-General Sir Percy Sykes with accurate information. They bought and laid out supplies for his troops, and their wives nursed the wounded. They calmed fanatical mobs. They headed rescue parties to save line-guards in winter blizzards. Forty years ago, the average number of messages passing along the lines was rarely more than 30 daily, and it took four days for a message to reach India from England. In 1930 the number of messages exceeded 2,000 in a day, and the delay in transmission was less than half an hour. A concession for the British operation of the Persian trunk lines, which expired in 1905, had been renewed to 1916, and a further renewal to 1945 was then arranged with the Persian Minister of Posts and Telegraphs; but at the time of the abolition of the Capitulations in 1928, the Persian Government, who desired to operate the lines themselves, claimed that the last renewal had not been ratified by the *Mejliss* (Parliament). Because of this contention, and of the Cable and Wireless Merger, the Indo-European

[1] Memoirs of Colonel Sir John Underwood Bateman-Champain, K.C.M.G., late R.(B.)E., appear in *The R.E. Journal*, Vol. 17, pp. 56–60; in the *History of the Corps of Royal Engineers*, by Major-General W. Porter, Vol. II, pp. 530–533; in *Addiscombe. Its Heroes and Men of Note*, by Colonel H. M. Vibart, pp. 603–608; and in *The Royal (Bengal) Engineers*, by Colonel Sir E. T. Thackeray, V.C., K.C.B., pp. 235–252.

[2] *A History of Persia*, by Brig.-General Sir Percy Sykes, K.C.I.E., C.B., C.M.G., Vol. II, p. 368 (3rd Edition, 1930). Sir Percy Sykes commanded our troops in South Persia from March, 1916, to December, 1918.

Department and Company handed over their plant and left Persia in March, 1931. Thus England no longer controls an important part of her link with India. But the achievements of her military telegraphists remain ; and the names of Goldsmid, Patrick Stewart, Bateman-Champain, Murdoch Smith, St. John, Pierson and Wells will always live in the annals of Persia.



THE CITY OF ORMUZ, IN THE PERSIAN GULF. A.D. 1574.

CHAPTER XVI.

MINTS.

ALTHOUGH military engineers have laboured in almost every branch of the civil administration in India, their services are no longer needed in many of these departments, and in the remainder, with one exception, their numbers are rapidly diminishing. The exception is the branch of the Finance Department which includes the Indian Mints. The control of the Mints has rested with Royal or Company's Engineers since the middle of the last century, and it remains their prerogative to this day. The training of these officers fits them for an employment which carries duties and responsibilities of a peculiarly varied and onerous nature, including not only mechanical and electrical engineering, metallurgy, chemistry and numismatics, but the organization, administration and management of concerns which employ many hundreds of skilled operators.

There are no textbooks on minting. Information must be gathered from scientific treatises and Government reports, supplemented by the results of experiments and tests. Many of the military Mint Masters of India have joined the Mints after establishing their reputations in railways or other public works. Baird Smith and Ballard had already distinguished themselves as soldiers ; and others, after becoming Mint Masters, reverted to military duty in time of war and resumed their civil appointments when hostilities had ended. But almost all who specialized in Mint management finished their Government service in that or similar employment, for the work is of absorbing interest, and well suited to those who prefer a settled billet in a large city to the frequent changes of a purely military career.

The histories of the Indian Mints do not lend themselves to combination in one chronological narrative. The existing institutions in Bombay and Calcutta are separated by the breadth of India ; and although both are under the control of the Finance Department, and work in co-operation, they often cater for different demands. Consequently it is preferable to trace the history of each Indian Mint in turn, beginning with the institution, once located in Madras, which was the first of its kind in India.

Permission to establish a Mint at Madrasapatam (Madras) formed one of the clauses of the grant which Francis Day received from the Naik of those parts on August[1] 22nd, 1639, when reconnoitring the

[1] The *farman* appears in Original Correspondence Series, No. 1,690, under the date *July* 22nd, 1639 ; but as Day did not reach Madras until July 27th, the correct date is probably *August* 22nd. (See *Vestiges of Old Madras*, by Colonel H. D. Love, Vol. I, p. 17.)

Coromandel Coast for a settlement south of Masulipatam and Armagon.[1] "The said English Company," it was written, "shall perpetually Injoy the priviledges of mintag[e] without paying any Dewes or dutyes whatsoever, more then the ordinary wages or hire unto those that shall Quoyne the moneyes." The grant having been engraved upon a gold plate to ensure its preservation, Francis Day and Andrew Cogan established a Mint at Madrasapatam soon after the foundation of the new settlement in February, 1640. Coining seems to have been restricted at first to gold pagodas[2], and was done on contract at a small profit by native traders called "Chetties." When the dies or moulds had been prepared, native goldsmiths were capable of refining the metal and striking or casting the coins; but so many abuses crept in that about the middle of the seventeenth century the British took over the supervision of the coining. At that period a great variety of coin was current. Silver rupees were not coined in Madras, but the British imported silver dollars or "ryalls of eight" (value 5s.) in large quantities. In addition to the gold *pagoda* they coined the gold *fanam*[3] (value 3d.) of very inferior alloy, and also copper money called *cash*, of which eighty went nominally to a *fanam*, though the smallest coin actually stamped was the four-cash piece. Anyone could bring bullion to the Mint for conversion into coin, but it was a criminal offence to coin money elsewhere. In 1686 the East India Company were permitted by King James II. to coin silver rupees at Madras (value 2s. 3½d.), and in the following year the Directors ordered that such coins should be struck; but the Madras Council resolved to strike silver *fanams* only, and to defer the coining of rupees.

The only military engineers in Madras in these early days were "Gunners," taken from ships,[4] who were much too closely occupied in building and repairing Fort St. George to interest themselves in melting bullion or stamping coins. The supervisors of the minting operations were civil servants. It is recorded in 1671[5] that "The Governour hath ordered Mr. Joseph Hynmers to take the care of the Chowtrey.[6] Mr. Hynmers is a person very able and very sedulous in business, and loves to be at it. Hee doth also take the care of the coyneing, which is no small trouble to him, notwithstanding the helpe hee hath provided by Mr. Gofton and Mr. Keble, the first whereof is under so deepe a Melancholy that makes him avoid all company and converse. I have appointed Mr. Hynmers to put him fully upon business about the coynage, if it may be to divert his Melancholy."

[1] See Vol. I, Chapter I, p. 4.

[2] The gold pagoda was then the standard coin of Southern India and worth about 8s. 4d. It was ⅝-inch in diameter, and impressed with the figure of Vishnu emitting rays. The reverse was plain.

[3] The coinage of gold *fanams* ceased in 1693.

[4] See Vol. I, Chapter I, regarding Gunners Jeremy Roote, John Morris, Christopher Wilkins, Hugh Dixon and William Dixon.

[5] Original Correspondence Series, No. 3575, September 6th, 1671.

[6] *Choultry*. Court of Justice.

The enthusiastic Hynmers and his sorrowful satellite were two of a long line of Assay Masters whose doings, unfortunately, cannot be recorded in these pages. Mention may be made, however, of a certain Edward Edwards who was appointed from the Royal Mint in London in 1749. Edwards refused to instruct others in the art of assaying, and consequently incurred the wrath of Governor Pigot in 1757. A heated interview took place, which Pigot ended by exclaiming: "Dam' ye, Sir, go out of my sight, or I will put you under arrest." Edwards was then ordered by the Council "to deliver charge of the Mint to one Pybus, who now has the Care of it, and says he can make an Assay as well as Mr. Edwards: however, the beauty of it is, no Person will trust him with Gold or Silver." In the end the Directors sided with Edwards and reinstated him as Assay Master.[1]

The Madras Mint had a chequered career. Towards the end of the seventeenth century it was rebuilt at the southern end of some barracks in the Inner Fort of Fort St. George, where it produced both gold and silver coins. A few years later, a separate Silver Mint was provided in the north-west salient of White Town outside the Inner Fort. This Mint was enlarged in 1717, and rebuilt before 1728. It was demolished by the French when they remodelled the fortifications of Fort St. George after capturing the place in 1746,[2] and re-erected by the British when they returned in 1749. A new Silver Mint was built near the Royal Bastion during the Third Mysore War in 1792; but the Gold Mint continued to be located in the Fort Square (the Inner Fort) until it was demolished early in the nineteenth century. All minting was then concentrated in one building.

During the greater part of the eighteenth century the Governors of Madras were nominally the Mint Masters. For instance, in 1754, Governor Thomas Saunders was styled "President of the Council, Cash-Keeper and Mint Master" and received a handsome allowance for the last-named appointment. In 1800, however, Lord Clive severed the connection of the Governor with the Mint, and the combined duties of Assay Master and Mint Master were assigned to the Sub-Treasurer, who was also the Paymaster. This system of control seems to have been maintained for many years until the advent of the first military Mint Master in Southern India.

Captain John T. Smith, of the Madras Engineers, infused new life into the Madras Mint when he was appointed Mint Master in February 1840. He was then engaged in building the Madras Lighthouse,[3] and seems to have divided his attention between this and the Mint. For a period of 15 years he held charge of the Mint, and during that time brought it to a state of great efficiency, introducing steam machinery and improved methods of minting, and thoroughly reforming the

[1] *Vestiges of old Madras*, by Colonel H. D. Love, Vol. II, p. 491.
[2] See Vol. I, Chapter V, p. 68.
[3] See Chapter X, p.180.

whole establishment. Although the accounts of the Bombay and Calcutta Mints were permitted to show very heavy items of waste, Smith would not allow such entries at Madras. He maintained that there could be no destruction of precious metals, and accordingly that every atom received should appear in the accounts of issues, either as actual coins, or in the sweepings of the rooms, which could be assayed. Another innovation which he introduced was the system of adjusting the weights of the " blanks "[1] by means of the diameters of the pieces, instead of by their thicknesses, which had been the previous custom. For this method he produced a most ingenious machine by which 20 or 100 blanks could be weighed to half a grain and deposited in a separate cell by two motions of the hand. After the pieces had been thus sorted, they were passed through a set of circular cutters which removed any excess of weight over the standard. By this means almost all the blanks were obtained of the exact weight without further correction.

Smith was absent on sick leave in South Africa during 1846 and 1847, but then returned to Madras and held his appointment as Mint Master until September, 1855, when he was transferred as Mint Master to Calcutta. A few months later he went to England to select and send out machinery for the minting of copper. He was one of four picked officers transferred at the same time to Bengal, the others being Major (afterwards Colonel) Jasper H. Bell, M.E., as Secretary, P.W.D., Captain (afterwards General) Francis H. Rundall, M.E., as head of the Irrigation Department in India, and Lieutenant (afterwards Major-General) Felix T. Haig, M.E., as head of that Department in Bengal. While on leave at the Cape, Smith wrote a volume (of 186 pages) entitled *Observations on the Duties and Responsibilities involved in the Management of Mints*." This he did because the Court of Directors had ordered in 1844 that a code of uniform regulations should be prepared for the government of the various Indian Mints. During his tenure of the Madras appointment he also wrote five professional papers on minting and currency.[2] Smith did not remain long in Calcutta, for the records show that Major Jasper Bell,[3] who succeeded him as Mint Master at Madras, was officiating for him in Calcutta during 1857 and part of 1858. In the latter year Smith left the Mint Department to become Consulting Engineer to the Madras Irrigation Company, a post which he occupied for many years. Later he became a Director of the Madras Railway Company

[1] Plain discs of gold, silver or copper, which are afterwards stamped to form coins.

[2] These appear in *Professional Papers of the Madras Engineers*, Vol. 2, 1859. The subjects are " A Defect in the System of Currency " (pp. 41–45) ; " The Occurrence of Waste in Coinage " (pp. 127–140) ; " An Assorter's Scale and Weighing Machine of a New Kind " (pp. 169–180) ; " A New System of Adjusting Coins to the Standard in Weight " (pp. 205–214) ; and " A Postscript to the Memorandum on Waste " (pp. 215–216).

[3] A memoir of Colonel J. H. Bell, late M.E., appears in *The R.E. Journal* of August, 1895.

and of the Delhi Bank, and finally Chairman of the Madras Railway. As a Fellow of the Royal Society, and of the Society of Actuaries, and an engineer whose activities were spread over the design and construction of lighthouses, the processes and administration of mints, and the management of irrigation and railway companies, Colonel John Smith deserves a prominent place among his contemporaries. He died in London in 1882.[1]

With Smith's departure to the Bengal establishment in the autumn of 1855, the life of the Madras Mint began to draw to a close. Lieut.-Colonel Jasper Bell, M.E., returned to his post as Mint Master in Madras in September, 1858, when Lieut.-Colonel Richard Baird Smith, C.B., B.E., of Mutiny fame, became Mint Master in Calcutta; and Bell was succeeded in 1860 by Major (afterwards Major-General) C. A. Orr, M.E., the designer and builder of the Kistna irrigation works.[2] Orr was followed in November, 1863, by Lieut.-Colonel John Carpendale, M.E. These three military engineers—Bell, Orr and Carpendale—worthily maintained the standard set by Smith, but the operations of the larger Mints in Bombay and Calcutta were rendering a third institution unnecessary. On September 1st, 1869, all coining ceased in the Madras Mint. The closing of its doors severed a link with the earliest days of British rule in India.

Bombay, a younger settlement than Madras, struck its first rupees (trial pieces) in 1672. There are four rupees in the British Museum, coined in the Bombay Mint, whose dates range from 1675 to 1678. But for several years before these coins were struck the minting of money in the western settlement had been under consideration. Bombay Island having been leased to the East India Company by King Charles II. on March 27th, 1668,[3] the Court of Directors desired to establish an English currency as quickly as possible. On February 22nd, 1671, they wrote to their servants at Surat:[4] "Wee doe thinck it convenient for us to have a coyne of our owne there [at Bombay]. Wee would have you therefore consider of such a coyne, soe as it bee not our Kings Majesties or any stampe resembling the same, and of such sorts as will best suite with the traffique and exchange of the country, both in bigger and lesser speties. . . . Wee would not have you coyne any copper or other inferiour mettall before you coyne gold or silver, for to begin with that would be a disparagement to us."

Some delay occurred, but President Aungier wrote on December 21st, 1672,[5] that he had begun to erect a Mint at Bombay to coin

[1] Memoirs of Colonel John T. Smith, F.R.S., late Royal (Madras) Engineers, appear in *The R.E. Journal*, Vol. 12, 1882, pp. 160–161, and in *Addiscombe. Its Heroes and Men of Note*, by H. M. Vibart, pp. 386–390.

[2] See Chapter II, p. 25.

[3] See Vol. I, Chapter II, p. 16.

[4] Surat, lying north of Bombay, was the first British settlement in India, having been established in 1612. It remained the headquarters of the East India Company for many years.

[5] Original Correspondence Series, No. 3,722. *Factory Records, Bombay*, Vol. VI.

silver, copper and tin and had collected some bars of silver and a number of *cruzadoes*.[1] He had decided that four sorts of coin would be required. These included gold coins, which he proposed to call *carolinas* in remembrance of King Charles; silver to be known as *anglinas*; copper to be styled *copperoons*; and tin money to be called *tinnys*.[2] Eleven *tinnys* went to a *copperoon*, and 48 *copperoons* to an *anglina* or Bombay rupee, whose value was about 2s. 6d. The coins were to have Latin inscriptions on both faces. However, as the Directors were doubtful whether their servants in India were justified in coining and issuing money without the King's authority, they stopped Aungier's fanciful coinage and obtained the Royal assent in October, 1676, to establish a Mint at Bombay to coin money of gold, silver, copper, tin, lead or any metal compounded of these. The coins were to be current in the East Indies and to be called *rupees*, *pices* and *budgrooks*.[3] The first Imperial rupee—a silver coin bearing the royal arms and the legends "By authority of Charles the Second" and "The Rupee of Bombaim"—was struck in the Bombay Mint in 1677, and with this the regular issue of dated coins appears to have begun.[4] Gold rupees were struck for the first time in 1765, and gold *mohurs* (15 rupees) in 1774; but four years later the coinage of gold rupees was discontinued. Gold coinage was revived for a time at the beginning of the nineteenth century. Nevertheless it may be said that silver and copper coinage held the field for many years before the present Mint was built.[5]

Although the precise position of the original Bombay Mint is uncertain, it is believed to have stood near the Town Barracks in the portion of the settlement known as "Bombay Fort." The work of coinage was carried on by a Mint Contractor, supervised by an Assay Master, and latterly also by a Mint Master and a Mint Committee. It seems that the first Assay Master, a Mr. Smith, was appointed in 1676 on the munificent salary of £60 per annum! When communication between different parts of India was so slow and uncertain, it was only natural that Mints should spring up in many places to keep pace with the expansion of trade, and, early in the nineteenth century, subsidiary Mints existed at Surat and Broach, north of Bombay, and at Poona, Saugor, Benares and Farrukhabad, in addition to the large institutions in the three Presidency towns. In October, 1815, however, the Bombay Government decided to concentrate all coinage operations for their Presidency in the Bombay

[1] Portuguese silver coins, about 3s. 6d. in value.

[2] *Anglinas* and *copperoons* may be seen in the British Museum. There is no evidence that gold *carolinas* were ever struck.

[3] *Bazaruccos, Bujruks*. These tin or lead coins, of value about 1/12th anna (= 1 pie) were already struck by the Portuguese at Goa. Another current Portuguese coin was the *Xeraphin*, a silver piece of value about 1s. 8d.

[4] "A Note on the First English Coinage at Bombay," by W. Foster (1906). Reprinted from the *Numismatic Chronicle*, 4th Series, Vol. VI.

[5] In the present Bombay Mint, gold coins were struck in considerable quantities only in 1845–46, 1849–51, 1856–57, and during the Great War.

Mint, and to abolish the Surat and Broach Mints.[1] Other presidencies followed suit. The Benares Mint was closed in 1830, and the Saugor Mint in 1835, so that when military engineers made their first appearance as Mint Masters, only the Madras, Bombay and Calcutta Mints remained.

The decision of the Bombay Government in 1815 led to the erection of the present Bombay Mint, designed and constructed by Captain (afterwards Major) John Hawkins, F.R.S., of the Bombay Engineers. The building was commenced in 1824, and finished in 1829, on a large area originally reclaimed from the sea[2] and lying close to the Dockyards and Arsenal. Thirty-six lakhs of rupees were spent on the scheme, including 16 lakhs on the building itself and $7\frac{1}{2}$ lakhs on machinery. Drawings were supplied from Madras of the machinery which had been in use there since 1812, and also a copy of the Madras Code of Rules. The Mastership of the new Mint was held by a senior financial official, Mr. J. D. Divitre, shortly followed by Mr. James Farish;[3] but Hawkins was appointed "Mint Engineer" in addition to his duties as Inspecting Engineer of the Presidency, and so remained until his death in February, 1831. He was a tireless worker. When his mechanics or millwrights were sick, he did their work with his own hands. He trained his assistants and apprentices, and a number of soldier artificers, and also supervised the work of three marine engineers who were placed under his orders. As the science of steam engines was in its infancy, he was often called upon to undertake work for the Navy, the Dockyard, the Arsenal and the Gun-carriage Factory with the help of his assistants, Lieutenants F. McGillivray, Bo.E., and G. Fulljames, Bo.I., and later of Lieutenant (afterwards General) H. Blois Turner, Bo.E., who took McGillivray's place in 1830 and was Mint Engineer from 1838 to 1847.[4] Three years before Blois Turner assumed office, the coinage of British India was made uniform and of the same denomination as that of the present day. The capacity of the Bombay Mint has been enlarged from time to time during the last 100 years, and gold and silver refineries have been built; but the fact that the original quadrangular buildings are in use to-day, with only minor alterations, is a tribute to the ability of Major John Hawkins.

Much dislocation in the work of the Bombay Mint was caused by frequent changes of Mint Masters, so it was suggested that, as in the

[1] The Broach Mint was a small Copper Mint under the control of the Collector.

[2] The area was reclaimed gradually under the Mody Bay Reclamation Scheme, and measured 49,000 square yards. (See *Gazetteer of Bombay City and Island* (1910), Vol. III, p. 307.)

[3] The civilian Mint Masters who preceded the military engineers in charge of the Bombay Mint were Robert Stewart (1813), F. Bourchier (1823), J. D. Divitre (1828), James Farish (1830), B. Doveton (1836), W. C. Bruce (1840) and W. Simson (1849).

[4] Several young Bombay Engineers served in the Mint as Assistants to McGillivray or Blois Turner. For instance, 2nd-Lieutenant J. Skirrow joined in 1834, and Lieutenant J. J. F. Cruickshank in 1836; and Lieutenants J. Estridge and W. S. Stuart assisted Blois Turner when he was Mint Engineer.

Calcutta Mint, and in the Madras Mint from 1840, the posts of Mint Engineer and Mint Master should be amalgamated. Red tape was rampant. A certain "Mint Master and Civil Auditor" addressed a letter from himself as Civil Auditor to himself as Mint Master, and finally sent it to the Mint Engineer to furnish the required information. There were actually four appointments in the Mint—Mint Master, Deputy Mint Master, Mint Engineer and Assistant Mint Engineer—and it was not until 1853 that these were combined in the person of Captain James H. Burke, of the Bombay Engineers, who was the first military officer to hold the Mastership of the Bombay Mint.[1]

Captain James Burke had had the advantage of being Mint Engineer for several years before he became Mint Master. He did well as head of the Mint from 1853 to 1862, but the work and responsibilities told heavily on him, and he was absent on sick leave throughout 1857 and 1858.[2] A new copper minting department, with six new coining presses, having been sanctioned by Government, the necessary additions to the Mint buildings were begun in 1860 after Burke had resumed charge.

The control and management of His Majesty's Mints is serious and responsible work. Yet humour may be found even within the precincts of those closely-guarded and well-regulated institutions. Mention of coining presses calls to mind the tale of the lady visitor to one of the Indian Mints. Handling some coins fresh from a press, she dropped them hurriedly with the exclamation, "Oh! Aren't they hot!" "So would *you* be, madam," was the reply, "if you had been squeezed like those coins."

The most famous of all the military engineers who had charge of the Bombay Mint was Lieut.-Colonel (afterwards General) J. A. Ballard, C.B., R.(Bo.)E., who succeeded Lieut.-Colonel James Burke as Mint Master and Currency Commissioner early in 1862, and held these appointments for no less than 17 years. His name is perpetuated in the Ballard Pier, the real gateway of India, and also in Ballard Road, for it was due to his foresight and acumen as Chairman of the Bombay Port Trust that an extensive reclamation of the foreshore to the north-east of the Mint, and the building of an

[1] An excellent history of the Bombay Mint from 1824 onwards is given in an article entitled "Military Engineers in the Bombay Mint," by Major D. Fitz J. Fitzmaurice (R.E., retired), Officiating Mint Master, Bombay, appearing in *The R.E. Journal*, Vol. XLV, January–June, 1931, pp. 259–273. The list of the military Mint Masters of Bombay, with their dates of appointment, is as follows:—Captain J. H. Burke, Bo.E. (1853); Lieut.-Colonel J. A. Ballard, R.(Bo.)E. (1862); Lieut.-Colonel J. H. White, R.(Bo.)E. (1879); Lieut.-Colonel R. V. Riddell, R.(B.)E. (1889); Major Buchanan Scott, R.E. (1895); Major G. Davidson, R.E. (1897); Lieut.-Colonel G. M. Porter, R.E. (1902); Major W. G. R. Cordue, R.E. (1905); Major A. L. C. McCormick, R.E. (1910); Major G. H. Willis, R.E. (1915); Major R. E. Stace, R.E. (1923); and Major A. J. Ransford, R.E. (1929). Many R.E. officers have officiated in the appointment.

[2] During this period Captain (afterwards Major-General) W. F. Marriott, Colonel Blois Turner, Lieut.-Colonel J. H. Graham-Crawford and Captain Francis Wemyss, all of the Bombay Engineers, officiated for Burke.

GENERAL J. A. BALLARD, C.B., LATE ROYAL (BOMBAY) ENGINEERS.

ocean quay to accommodate large liners, were initiated. Ballard was the most distinguished soldier who ever managed an Indian Mint. Lieut.-Colonel Richard Baird Smith is known to all the world as the engineer in supreme charge of the siege operations at Delhi in 1857 before he became Mint Master in Calcutta, but he never led a brigade of infantry in battle as Ballard did while still a subaltern.

In 1854, after four years' service in India, young Ballard happened to be voyaging homewards when stirring events induced him to turn aside at Constantinople. A Russian army was marching to besiege the Turks in Silistria on the Danube near the Black Sea, and British and French transports were concentrating troops at Varna. Ballard joined an army of 45,000 Turks under Omar Pasha at Shumla, 60 miles south of Silistria, and was sent on to Silistria bearing orders to the local Turkish Commander. He reached the place on June 13th and helped to defend it until the Russians drew off on the 23rd. The Turks greatly appreciated the work of the young British Engineer, who had been commissioned as a Lieut.-Colonel in their army. He directed their counsels, and kept them in good heart by his coolness and optimism. When the Turks advanced across the Danube on July 1st, Ballard commanded their skirmishers. Then he left them to continue his journey to England ; but he could not keep away from the fighting and was back on the Danube in November. In December he landed with Turkish troops in the Crimea, and was present at the battle of Eupatoria on February 17th, 1855. A few months later he served with the Turks at Sevastopol, and in an expedition to Kertch, at the eastern end of the Crimea ; and finally, in September, 1855, at the age of 25 years, he commanded a Turkish brigade in the successful battle of the Ingour River. For his services on behalf of the Allies he was made a Companion of the Bath while still a Lieutenant. Afterwards he accompanied the expedition to Persia in 1856.[1] and then returned to India to act as Assistant Quartermaster-General to Colonel H. E. Roberts in the operations in Rajputana during the Indian Mutiny. Such was his record before he joined the Bombay Mint. Perhaps he was tired of war ; but his friends deplored his decision to enter civil employment. A field-marshal's baton might have awaited him in military service.

Soon after Ballard became Mint Master in 1862, there was a very heavy demand for coinage. So much bullion was tendered that it became necessary to send some of it to Madras and Calcutta. A new rupee was introduced, bearing on the obverse the crowned head of the sovereign and the inscription " Victoria Queen," while the reverse no longer carried the inscription " East India Company." The Mint Committee was abolished in 1863, shortly after the issue of the first Treasury notes through the Currency Office. These and other innovations threw heavy work on the new Mint Master, and

[1] See Vol. I, Chapter XVI, p. 312.

afterwards on the officers who officiated for him during his absence on duty in Calcutta in 1866 and 1867, and on leave in New Zealand from March, 1871, to February, 1872.[1]

It was after his return from New Zealand that Ballard was made Chairman of the Bombay Port Trust, a most responsible post which he filled with credit in addition to that of Mint Master. During his next furlough in 1876, a notable change in the administration of the Mint was announced. The opening of the Suez Canal in 1869 had increased the importance of the Bombay Mint, and the abolition of the Madras Mint in the same year had thrown extra work upon it. Consequently the Government of India had decided that in future the Bombay Mint should be administered directly by them and not by the Bombay Government. The Calcutta Mint was already under the direct control of the Central Government. Ballard was back in India in January, 1878, but he saw little more of Bombay as he was deputed at once to Calcutta to advise the Government of India on currency questions.[2] On February 7th, 1879, shortly after his retirement as a General, he handed over charge of the Bombay Mint at the early age of 48 years, and proceeded to Europe. Sad to say, he died in Greece within the next three months. Few officers have risen so rapidly by sheer ability. None has earned more thoroughly the friendship and admiration of his contemporaries.[3]

There is little of general interest to record in the history of the Bombay Mint during the next 18 years while Lieut.-Colonel (afterwards Major-General) J. H. White, R.(Bo.)E., Lieut.-Colonel R. V. Riddell, R.(B.)E., and Major (now Colonel Sir Buchanan) Scott, R.E., held office in turn. Although some new coining presses of lever type were introduced in 1886–87, White preferred the old screw presses, which are in use to this day after 70 years of hard service. In 1893, while Riddell was Mint Master, the unrestricted coinage of bullion tendered by the public was stopped, and Government thereafter controlled the quantity of coin put into or withdrawn from circulation, a system which is still in force. From 1893 to 1900 the work of both the Indian Mints was fairly light; but during the financial year 1900–01 they were suddenly called upon to face an unprecedented pressure in the form of a heavy rupee coinage, and Major George Davidson, R.E., the Mint Master at Bombay, issued coinage to the value of 1,114 lakhs of rupees. When the demand abated in 1902, towards the close of the South African War, Lieut.-

[1] During 1866–67, Colonel (afterwards Major-General) J. Harley Maxwell, late R.(B.)E., and Captain (afterwards General Sir) E. C. Sparshott Williams, R.(B.)E., officiated for Colonel Ballard. In 1871–72, Colonel (afterwards Lieut.-General) Jenkin Jones, late R.(Bo.)E., officiated for him.

[2] During 1877 and 1879, Lieut.-Colonel (afterwards Major-General) J. H. White, R.(Bo.)E., officiated for Major-General Ballard in Bombay. This was a difficult period, including a famine and a heavy demand for small coinage.

[3] Memoirs of General J. A. Ballard, C.B., LL.D., late Royal (Bombay) Engineers, appear in *The R.E. Journal*, Vol. 10, 1880, pp. 184–189, and in *Addiscombe. Its Heroes and Men of Note*, by H. M. Vibart, pp. 560–568.

Colonel G. M. Porter, R.E., who had succeeded Davidson, took advantage of the easier conditions to withdraw and re-coin the first two issues of "Victoria Queen" rupees. Coinage of British dollars for Hong Kong was continued, and also the re-coinage of rupees for Native States. On January 1st, 1903, the King Edward VII. rupee made its first appearance, followed by the Straits Settlements dollar. Then came another period of pressure. In 1905–06, the Bombay and Calcutta Mints produced three-eighths of the total out-turn of all the other Mints in the world; and in 1906–07, under Major W. G. R. Cordue, R.E., the Bombay out-turn alone reached the value of 1,607 lakhs of rupees.

The Bombay Mint struck out a new line on August 1st, 1907, when it issued the first one-anna coin of so-called nickel. The coin was actually composed of an alloy of one part of nickel to three parts of copper. With a waved edge, having 12 scallops, it was readily distinguishable by touch. Many experts had maintained that the manufacture of a satisfactory coin with a scalloped edge was impracticable; but, for many years, the Calcutta Mint had been coining tokens for the tea-gardens in shapes other than circular. Captain A. L. C. McCormick, R.E., who was officiating for Major Cordue in 1905–06, secured the coin a fair trial. The skill and perseverance of the Mint engineers triumphed over the mechanical difficulties of manufacture. The one-anna nickel piece, equivalent to a British penny, soon flooded India, and still holds the field as the most useful coin in the country. Two annas will secure the services of a diminutive caddy for a nine-holes round of golf in a small up-country station, or of a full-grown porter on a railway platform. Four annas will feed a villager for a day. In spite of retrenchment, taxation and self-government, money still goes a long way in the wide areas of India, which have altered so little since the days of John Company.

A curious problem confronted the Indian Mints in 1911. Certain Muhammadans had objected to the design of the elephant appearing on the obverse of the first issue of the King George V. rupee. The elephant was on a very small scale, and was made long and low, which deformity, combined with the peculiarity of a short and thick trunk, caused the Muhammadans to allege that the animal bore a strong resemblance to a pig. Ever anxious to avoid giving offence to any section of the community, the Government then directed that this particular issue should be withdrawn from circulation. Coining of the issue ceased, and the Mint Masters, no doubt, made a close study of every elephant they met. Other issues were then struck from obverse dies most skilfully altered by Mr. Wezel, the Engraver of the Calcutta Mint, and the noble quadruped reappeared with a nasal appendage of such elephantine proportions that his identity was unmistakable.

At this time, the electrification of the machinery in the Calcutta Mint having been recently carried out by Captain G. H. Willis, R.E., Major A. L. C. McCormick, R.E., the Mint Master in Bombay, forwarded proposals for the replacement of his old steam engines by electric motors. The Bombay Mint had had the benefit of electric light and fans since 1907, when they were installed by Major W. G. R. Cordue, R.E., one of the most expert and experienced of Mint Masters. The electrification project at Bombay, however, did not prosper until McCormick submitted a scheme in July, 1914, based on a report prepared by Captain R. E. Stace, R.E., who had joined his staff in March. Sanction having been received, Stace made preparations for the work; but shortly afterwards he proceeded on field service to Mesopotamia, where he was subsequently taken prisoner when Kut-al-Amara fell to the Turks.[1] Prices soared in 1915 during the Great War, and the delivery of machines could not be guaranteed. Stoppage of work in the Bombay Mint, even for a few days, could not be contemplated. The energies of both the Indian Mints were directed to special war work and an increasingly heavy programme of coinage, and the electrification of the Bombay Mint was postponed and was not carried out until three years after the war had ended.

The activities of the Bombay Mint, under Major G. H. Willis, M.V.O., R.E., during and after the Great War, were many and varied. While the war lasted, work continued almost unceasingly, day and night. The outstanding features were the manufacture of some three-quarters of a million copper driving bands for shells, of standard gauges for shells and rifles, and of 60 motor ambulances. Enormous quantities of gold, in coin and in the form of ingots, were handled, much of it coming from South Africa, Russia, Japan and the United States. In 1917 the coinage of gold *mohurs* was approved, and subsequently over two million pieces were struck. A branch of the Royal Mint was opened in Bombay in August, 1918, having a stamping-room, a weighing-room and an assay laboratory, and more than $1\frac{1}{4}$ million British sovereigns were made with the help of a staff sent from London. The output of silver coinage during 1918–19 reached the unprecedented value of Rs. 2,457 lakhs. Egypt was catered for, and the Straits Settlements, and nickel coinage (both one- and two-anna pieces[2]) was produced for India.

In 1919, when hostilities were at an end, a gold refinery was built for raw gold and gold coin, and a chlorine process introduced. The

[1] See Vol. I, Chapter XXIII, pp. 485–487; and also *In Kut and Captivity* (1919), by Major E. W. C. Sandes, M.C., R.E., Chapters IX to XV, in which a full account is given of the defence of Kut-al-Amara and the part taken in it by R.E. officers. The experiences of these officers while prisoners in Turkey are recounted in the later chapters of *In Kut and Captivity*, and also in *Tales of Turkey* (1924) by the same author.

[2] The two-anna nickel coin was introduced in 1917–18, and is still in general use. It is square in shape with rounded corners. Four- and eight-anna nickel coins, introduced in 1919, have been withdrawn from circulation.

Bombay Mint sold large quantities of raw and refined gold on behalf of Government. On one occasion an Indian buyer of £75,000 worth of gold left the heavy bars on the steps of the main porch while he went to arrange for carriages. When asked why he was so foolhardy, he replied that he, like everyone else, had complete trust in the Mint, " even to the steps outside it." However, anyone who has attempted to lift a bar of gold will realise that the man had little cause for anxiety while the Bombay sun shone and brows were wet with honest sweat. Only once was a bar of the precious metal stolen, and this was in the city, through which consignments of gold were often conveyed by their owners in open carts or carriages, escorted by no more than one or two men.

After the Great War, Major R. E. Stace, R.E., returned to the Bombay Mint to assist Major Willis, and completed the electrification project, which was carried into execution between 1921 and 1924. He introduced the use of cylinder gas (chlorine) in the gold refinery, and secured better evacuation of the noxious fumes. A three-phase electric supply at 5,000 volts was available from the Bombay Supply Company; so a sub-station was installed in the Mint compound, with static transformers to step down to 400 volts, for delivery to alternating-current motors developing a total of about 740 horse-power. Although a British firm supplied the plant, the erection was carried out by Stace and his men. The electric plant soon proved to be much cheaper to work than the old steam plant, and three men sufficed to operate it instead of the thirty men formerly required.[1] During his tenure as Mint Master from 1923 to 1929, in succession to Willis, Stace designed and set up an electrolytic silver refinery with the assistance of Captain A. J. Ransford, R.E. This refinery was opened in 1929, when Ransford became Mint Master, and is still the best and largest of its type in the world. The Bombay Mint owes much of its efficiency to the indefatigable labours of Colonel Sir George Willis, C.I.E., M.V.O., and of his successor Lieut.-Colonel R. E. Stace, during the nine years which followed the outbreak of the Great War.

No coinage has been undertaken in the Bombay Mint since 1930. There is an excess of rupees in India, and smaller denominations are coined only in Calcutta. Retrenchment is the order of the day. The Mint Master now controls the Assay office, and the posts of Assay Master and Deputy Assay Master have been abolished. However, the Bombay Mint is still active. Since the departure of Great Britain from the Gold Standard in October, 1931, the flow of gold through the melting department (from merchants and banks for assay purposes) has been enormous, and on one day, December 28th, 1931, the Bombay Mint melted 4½ tons of it. Silver is also melted

[1] Article entitled " Electrification of His Majesty's Mint, Bombay," by Major R. E. Stace, R.E., Mint Master, Bombay, appearing in *The R.E. Journal*, Vol. XXXVIII, March–December, 1924, p. 487.

and refined to the amount of 18 million ounces a year. The furnaces have recently been converted to burn oil fuel, and other improvements have been made. Thus it will be seen that Major A. J. Ransford, R.E., the present Mint Master, and Major D. Fitz J. Fitzmaurice, R.E. (retired) and Captain D. V. Deane, R.E., successive Deputy Mint Masters, have worthily maintained the reputation established by a long line of military engineers extending back to 1824, when Captain John Hawkins laid the foundations of the Bombay Mint.

The earliest attempts to secure facilities for minting in Bengal were made during the seventeenth century. The British traders who sailed up the Hugli to Sutanuti in 1690[1] turned their attention to this matter before many years had passed. In 1698, Charles Eyre, the Company's Agent in Bengal, wrote to the Court of Directors :[2] " Being advised the Dutch have lately had admittance to the Prince [Nawab Azim-ush-shan[3]] and that he hath accepted the Present, wee are making preparations to forward ours, and have appointed Mr. Stanley to represent our Right Honourable Masters affairs. Wee have been much streighten'd for want of rarities to make up the present for the Prince, but have pick'd, out of what wee have, what wee think may be most acceptable, which with the Broad Cloth will amount to about 16,000 rupees, and have recommended to Mr. Stanley's care more particularly the defeating the Interlopers[4] and procuring a Mint at Hugly, which latter wee understand the Dutch are very Intent upon." In spite of these overtures, the British failed to establish a Mint at Hugli, and were obliged to buy permission to coin their bullion in the Mughal Mint at Murshidabad.[5] Murshid Kuli Khan, better known as Mir Jafar Ali, the *Diwan* or financial representative of the Mughal Emperor, having quarrelled with Nawab Azim-ush-shan, migrated from Dacca, the capital of Bengal, to Muxadabad, which he renamed Murshidabad ; and in 1706 he exacted Rs. 25,000 from the British in return for permission to build a factory at Cossimbazar to facilitate the coining of their bullion in Murshidabad. The efforts of the British to secure the minting of their money were not very successful and were certainly most expensive.

It is probable that the first British Mint in Bengal was established between 1757 and 1760, soon after Colonel Clive and Admiral Watson

[1] See Vol. I, Chapter III, p. 31. The British established a factory at Hugli, on the River Hugli, about 26 miles above Sutanuti (modern Calcutta), in 1650 ; but in 1688, under Job Charnock, they left Bengal. Returning to Sutanuti in 1690, they founded Calcutta.

[2] General letter, Bengal to Court, January 6th, 1698. Original Correspondence Series, No. 6,485.

[3] Mughal Governor of Bengal.

[4] Private traders, competing with the Company.

[5] *Bengal in* 1756–57, by S. C. Hill, Vol. I, Preface, p. xxiv. For the positions of Murshidabad, Cossimbazar, Dacca and other places, see Maps I and II at the end of this volume.

recaptured Calcutta from Siraj-ud-Daula; but it appears that the provision of a Mint had been under discussion before the Black Hole tragedy of 1756. Mention is made in a despatch from Bengal in 1753 of the need for the utmost secrecy regarding a proposed Mint, and of presents amounting to two lakhs of rupees to arrange matters. After the British returned as conquerors there was no more suggestion of "presents," but the strictest formality was observed. On January 21st, 1757, Clive wrote to the Nawab of Bengal asking that he would allow the Company to erect a Mint in Calcutta, endowed with the same privileges as the Mint at Murshidabad, and that if the Calcutta rupees were of equal weight and fineness with those of Murshidabad, they might pass current without the deduction of *batta* (discount). On February 6th he received a reply that "The Nabob agrees to give you back Calcutta with all the privileges of your *Phirmaund*[1] and whatever goods you lost at Cossimbuzar or elsewhere, and will grant you permission to coin *siccas*[2] in your Mint at Calcutta or Allenagar, and that you may make what fortifications you please in Calcutta." As Clive was already in full possession of Calcutta, the Nawab's bestowal of it on him was a typical piece of Eastern rodomontade designed to ease the bitterness of defeat.

The precise date of the establishment of Clive's Mint is unknown. One authority fixes the date as 1757, and states that the first rupee was struck on August 29th of that year. Another gives the date as 1759. The Calcutta *sikka* rupee, in deference to the Mughal domination, bore the Persian inscription "Defender of the Muhammadan faith, Reflection of Divine excellence, the Emperor Shah Alam has struck this coin to be current throughout the seven climes." The coins produced by the British were crude specimens, struck between dies with a hammer, and were mere counterfeits of the Mughal coins then in circulation. With such primitive methods, no special building would be necessary, and possibly none was built.[3]

Machinery was sent out from England in 1790, and coins of modern type, with milled edges, were then struck. The machinery was erected in two buildings, about a quarter of a mile south of Old Fort William, on the site of Gillett's shipbuilding yard, a locality which was taken over in 1833 by the Stamp and Stationery Committee. The site is probably the land between Strand Road and

[1] *Phirmaund*, *firman*, order, permission, grant.

[2] *Sicca*, *sikka*, current. Previous to the time of Farrukhsiyar (1712–19) all rupees coined under the reigning Mughal emperor were considered as *sikkas* and passed at their original value during his life. On the accession of a new monarch, rupees of a former reign were subject to a *batta*. Later, in the time of Shah Alam (1759–1806), all rupees not of the current year were subject to *batta*, but the East India Company decreed that all rupees from 1770 onwards were to be considered as *siccas* and of full value. The term *sikka* was subsequently used to distinguish these rupees from the next standard rupee. It still survives in Hyderabad State.

[3] Paper entitled "A Brief History and Description of His Majesty's Mint, Cal, cutta," read in 1929 by Major (now Colonel) M. Stagg, O.B.E., R.E., Mint Master-Calcutta, at a meeting of the Numismatic Society of India. The information in this paper has been used extensively in this narrative.

Church Lane now occupied by the Stationery Office. Included in the machinery was a rolling mill worked by 40 coolies, each paid Rs. 5 (say 11s.) per mensem, and it was found that four reliefs were necessary to roll the metal required to coin one lakh of rupees in 12 hours. It is interesting to compare this out-turn with that of the present day, when electrically-driven rolling-mills prepare, in seven hours, the metal needed for three lakhs of rupees. Melting was done in a large open fire of charcoal in which many small pots were placed. As there was no chimney, the heat and fumes were so oppressive that no one could supervise the work of the melters, who were thus able to abstract silver and substitute other metal with impunity. Although a melter was required to deposit Rs. 2,000, and was paid only Rs. 10 per mensem, there was no lack of applicants for the post.

The first Mint Master of Calcutta, whose name is on record, was a certain Robert Harris, who held charge prior to 1792[1] and headed a line of thirteen civilians, and one officer of the Bengal Infantry, before the first military engineer was appointed to the post.[2] In 1819 the Bengal Government decided that a new Mint was needed. The old houses near the riverbank were falling to ruin, and were too weak to contain new machinery. A young subaltern of the Bengal Engineers, named William Nairn Forbes, was accordingly sent to England to superintend the manufacture of machinery. He returned to Calcutta in 1823, and the foundation of the present Silver Mint was laid on March 31st, 1824. Thus the Calcutta Mint was founded in the same year as the sister institution in Bombay.

Lieutenant (afterwards Major-General) W. N. Forbes, B.E., was remarkable not only as an expert mechanical engineer, but as the architect of both the Silver Mint and St. Paul's Cathedral in Calcutta.[3] He left his architectural work to serve in the siege and capture of Bhurtpore in 1826,[4] but afterwards returned and completed the building of the Mint. Although the date of completion is stated to be 1831,[5] coinage was begun on August 1st, 1829. The façade of the structure, facing Strand Road, is in Grecian Doric style, and conceals the utilitarian buildings lying behind it. As the soil is alluvial, massive foundations were carried to a depth of about 25 feet below ground-level, and consequently much of the initial work was hidden

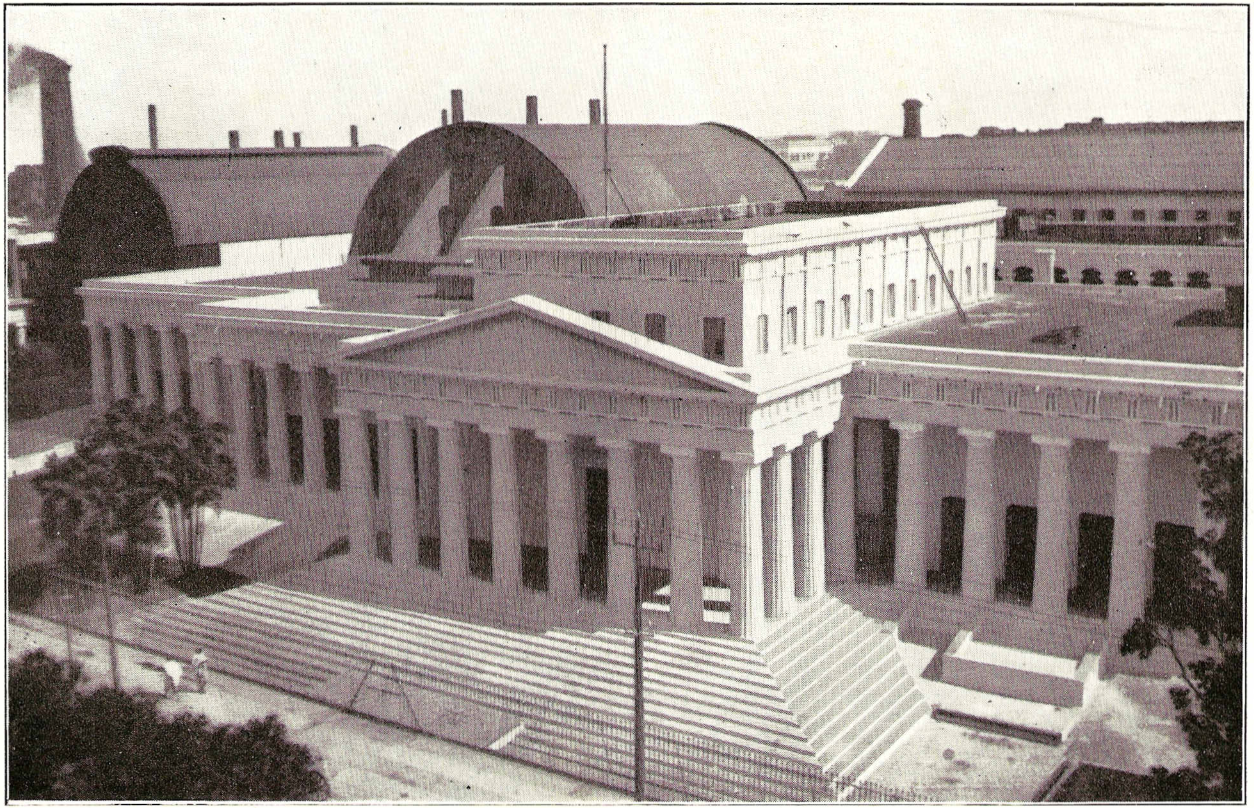
[1] The Park Street Cemetery, however, contains a tombstone, dated 1781, erected to the memory of a son of one *Herbert* Harris, Mint Master.

[2] The early Mint Masters of Calcutta were as follows:—Robert Harris (before 1792); James Miller (1792); Francis Mure, or Muir (1799); H. Chichele Plowden and Henry Foster (1802); George Davidson (1810); Horace H. Wilson (1813); Major Malcom Macleod (1814); George Saunders (1815); James MacNabb (1820); P. Y. Lindsay and H. H. Wilson (1824); John Trotter (1825); and Robert Saunders (1826). Of these the most notable is Horace H. Wilson, whose remarkable career is recorded in the *Dictionary of National Biography*.

[3] See Chapter VI, pp. 93, 94.

[4] The R.E. Museum at Chatham contains an Indian Army Medal, 1799–1826, with a bar "Bhurtpoor," awarded to Lieutenant W. N. Forbes, B.E., Sappers and Miners.

[5] *Calcutta. Old and New*, by H. E. A. Cotton, p. 914.



HIS MAJESTY'S MINT, CALCUTTA.

from view. Some high official happened to visit the site while Forbes was absent at Bhurtpore, and was alarmed to find that nothing showed above ground. Here was another scandal, thought he, comparable with that of the building of New Fort William by Captain John Brohier in 1760,[1] so he called for an explanation from Forbes when the latter returned from military service. This, of course, was readily given, and the correspondence was duly filed for the edification of posterity.

Expense was not spared in the building of the Silver Mint. Besides the solid foundations, an enormous quantity of masonry was laid in making subterranean tunnels for the condensing water of the primitive steam engines and for the flues of the chimneys. The buildings alone cost 11 lakhs of rupees, and the machinery a further 13 lakhs. This machinery was capable of coining two lakhs of silver pieces daily. It was similar to that which had been perfected by Boulton and Watt about 50 years earlier, and had been installed in the Royal Mint in London.[2] The coining presses supplied to Calcutta in 1829, and similar ones supplied in 1860, are still in use. Though bulky and very noisy, they remain the best for the production of large quantities of heavy coin, such as rupees.

On January 5th, 1836, some five years after he had completed the erection of the Silver Mint near Howrah Bridge, Captain William Forbes had the distinction of being the first military engineer to be appointed Mint Master in Calcutta.[3] He held this post until he died, as a Major-General, on May 1st, 1855, while on his voyage to England. Though absent on special duty in England during 1848 and part of 1849, when Lieut.-Colonel G. T. Greene, B.E., and Major W. N. Smyth, B.E., officiated for him in turn, he devoted his time and energies entirely to the Mint. After his death, the Court of Directors marked their appreciation of his services by placing a marble bust of him in the Alligation Department of the Mint, and erecting a memorial to his memory in St. Paul's Cathedral, Calcutta.

[1] See Vol. I, Chapter VII, p. 116.

[2] James Watt, the inventor of the steam engine, became a partner of Matthew Boulton, a manufacturer, in 1772, and in 1778 they set up coining presses at Soho, Birmingham, which were operated by steam plant. Boulton may be regarded as the father of modern minting. He supplied the machinery for the London, Bombay, and Madras Mints, and for many foreign mints. See *The Lives of Boulton and Watt*, by Samuel Smiles (1878). There is, in the Calcutta Mint, a fine collection of medals and coins struck at Soho, Birmingham, between 1780 and 1820.

[3] The list of military Masters in Calcutta, with the dates of their appointments, is as follows :—Captain W. N. Forbes, B.E. (1836) ; Lieut.-Colonel J. T. Smith, M.E. (1855) ; Lieut.-Colonel R. Baird Smith, C.B., B.E. (1858) ; Captain H. Hyde, R.(B.)E. (1862), and, as Lieut.-Colonel, 1868–71 ; Lieut.-Colonel J. A. Ballard, C.B., R.(Bo.)E. (1866) ; Colonel J. F. Tennant, late R.(B.)E. (1876) and 1881–84 ; Major R. V. Riddell, R.(B.)E. (1884) ; Lieut.-Colonel A. W. Baird, R.E. (1889) ; Lieut.-Colonel Buchanan Scott, C.I.E., R.E. (1897) ; Lieut.-Colonel G. M. Porter, R.E, (1904) ; Lieut.-Colonel W. G. R. Cordue, R.E. (1911) ; Major A. L. C. McCormick, R.E. (1915) ; Lieut.-Colonel G. H. Willis, M.V.O., R.E. (1923) ; Major M. Stagg. O.B.E., R.E. (1926). Majors C. H. Luard, R.(B.)E., R. E. Stace, R.E., and A. J- Ransford, R.E., have officiated as Mint Master, and also many of those in the fore. going list. Civilian Assay Masters have also officiated from time to time.

It may be well to explain that the duty of the Alligation Department is to calculate the quantity of copper required to bring the silver to the prescribed fineness of the coin to be minted. This is done on a form called the " Alligation paper," which is prepared by a clerk who is specially selected for the duty. And thereby hangs a tale. A visitor to the Calcutta Mint once asked this clerk what his work was. " Sir," replied the man, " *I am the Office Alligator.*"

In the early records of the Calcutta Mint, dating from 1792, there is much correspondence regarding escorts for treasure sent by boats on the river. It is recorded also that the Benares and Saugor Mints were established in 1820, and that their machinery was supplied by a Calcutta firm. Until English coinage was introduced in 1835 during the reign of King William IV., gold, silver and copper money was coined in the Calcutta Mint in the name of the Mughal Emperor at Delhi. The Indian Mutiny did not affect the Mint except that the subsequent transfer of India from the East India Company to the Crown necessitated that a new device should be stamped on the coins. This led to the issue of the 1862 rupee during the tenure of Captain H. Hyde, R.(B.)E., as Mint Master. The date of coins was not changed yearly as at present, partly because skilled engravers were scarce, but also because new matrices would have to be imported from England if any changes were made. Prior to 1874, when a yearly change of date was initiated, rupees were dated only 1835, 1840 or 1862.

The revival of trade and commerce after the Indian Mutiny, and the resulting expansion of minting operations, led to the construction of a separate block of buildings to the north-east of the Silver Mint in Calcutta for the coinage of copper alone. The foundations of the new Copper Mint were laid in 1860, and the building was opened in 1865. Until the Copper Mint existed, large quantities of copper coins were imported from England. For instance, in 1857, while Major J. H. Bell, M.E., was officiating as Mint Master, 300 tons of *pice*, struck in Birmingham, were sent to Calcutta and arrived there safely. This was not always the case, for several consignments were lost by shipwreck on the voyage to India.

The Silver and Copper Mints in Calcutta are self-contained, each comprising Melting, Laminating and Cutting, Annealing and Stamping, and Packing Departments. The Silver Mint has, in addition, an Automatic Weighing Department for the weighing of blanks before they are struck. The Bullion and General Offices, Workshops and Stores are common to both Mints. One thousand men work in these Mints under the control of Colonel M. Stagg, O.B.E., late R.E., the Senior Mint Master, who has administered these institutions, with marked ability, since 1926. The Silver and Copper Mints together form the Calcutta Mint, the largest of its kind in the world.

In addition to Government of India coins, the Calcutta Mint has

made regular issues of coinage for the Straits Settlements and Ceylon, and occasionally of British dollars for Hong Kong. Coins have been struck for Bhutan and for many Indian States, including Dewas, Bikaner, Dhar, Sailana, Udaipur and Pudukkottai. For the last-named State, the Mint struck a coin called the *Aman Cash* which is valued at only 1/16th anna. Orders for this diminutive piece are still received from time to time. Other coins which have been minted in Calcutta are the Portuguese Indian rupee, quarter *tanga* and eighth *tanga* of 1881–86 ; *pice* for British East Africa in 1888 ; coins for the Sultan of Lahej, near Aden, in 1895 ; and penny and half-penny pieces for Australia during the Great War.

The *pie* is the smallest British Government coin in India. Twelve of these little pieces go to an anna. But there is another minute coin called the half-pice, equivalent to an eighth-anna, which has more than once caused complications in accounting. Singly, it cannot be credited in Government accounts, because fractions of a pie are not allowed to appear, and the half-pice is equal to $1\frac{1}{2}$ pies. On one occasion a postman discovered a half-pice in a letter-box, and took it to the postmaster. The latter knew that, according to the rules, the coin should be credited to Government ; and this, also according to the rules, he was unable to do. So he sent it to His Majesty's Mint, transmitting it (again according to the rules) by registered and insured post and demanding an acknowledgment of its receipt. The half-pice reached the Mint and was duly acknowledged —and the cost of the whole transaction was 6 annas, or 48 times the value of the coin ! The Indian financial regulations are carefully planned to cover every conceivable contingency. But the designers of those intricate precepts failed apparently to legislate for the economical disposal of treasure-trove in the form of a solitary half-pice.

Medals and decorations are manufactured in large numbers in the Calcutta Mint. The earliest medal, of which the dies are now in the Mint, is that for Service on the Island of Ceylon (1795–96), and other early specimens are Seringapatam (1799), Egypt (1801), Isle of France (1809–10), Java (1811), Nepal (1814–16), Coorg (1837), and a series of Afghanistan medals of 1839–42. The Engraving Department possesses a silver replica of the famous Waterloo Medal. Only four of these medals were ever struck. They were of gold, and were distributed among the four allied sovereigns of Great Britain, Austria, Prussia and Russia, whose heads appear on the face. The reverse bears the heads of Wellington and Blucher. The first Indian General Service Medal was produced in Calcutta in 1854, and has no less than 20 clasps. Four later designs of this medal were provided with additional clasps, so that in 1929 the total number of clasps was 38 ! When Colonel Sir Buchanan Scott, K.C.I.E., late R.E., was Mint Master at the end of the last century, he had to meet an enormous

demand for medals for the numerous campaigns on the North-West Frontier. Anticipating the demand, he put the work in hand before the order reached the Calcutta Mint, with the result that he was able to despatch the first consignment of medals, with names engraved and clasps attached, immediately the instructions were received, and was thanked by Government for his promptitude. Other Mint Masters, both in Calcutta and Bombay, have been similarly honoured on more than one occasion. In connection with the Great War, the 1914–15 Bronze Star and the British War Medal were struck in large numbers in Calcutta by Lieut.-Colonel A. L. C. McCormick, C.I.E., R.E., who was Mint Master during that critical period. The familiar Indian military and civil decorations (18 in number), and many medals for universities, colleges and societies, are still produced every year. Thus it will be seen that the military engineers in charge of the Calcutta Mint are not concerned merely with the striking of coin and the melting of bullion.

In 1911 the responsible duty of casting the silver thrones to be used by Their Majesties King George V. and Queen Mary at the Delhi Coronation Durbar fell to Captain (now Colonel Sir George) Willis, R.E., who was officiating as Mint Master in Calcutta. These thrones were of Georgian design, and were facsimiles of others, of wood covered with sheet silver, which had been made in 1875. The wooden thrones were taken to pieces, and each piece was then used in making a mould for a casting in silver. The metal was obtained by melting 96,000 old rupees; and the completed thrones, with their silver footstools, weighed 1,911 lbs., a figure which, by a curious coincidence, corresponded with the year of their manufacture. The rough castings in silver were chased and engraved by Indian experts, and afterwards gilt by an electrical process. Some elaborate pieces, such as the massive lions forming the arms of the King's chair, required special treatment; particularly fine sand was needed for their moulds, and a suitable material was found at last in the silt at the bottom of the unfiltered water-supply cisterns of the Calcutta Municipality.[1] Owing to the delicate gilding and great weight of the thrones, they were sent in pieces to Delhi and assembled and upholstered there. The Delhi Durbar work of the Calcutta Mint did not end with the despatch of the thrones, for Willis produced 200 gold and 27,000 silver Durbar Medals within 16 weeks after the arrival of the necessary die from England.

Under Lieut.-Colonel A. L. C. McCormick, the Calcutta Mint worked at enormous pressure towards the close of the Great War. During the financial year 1918–19 nearly 546 millions of coins were struck, and on one day alone the output exceeded 18 lakhs of rupees, besides small coin. The Calcutta output for 1918–19 is almost

[1] Article entitled "Work Done by His Majesty's Mint, Calcutta, Delhi Durbar, 1911," appearing in *The R.E. Journal*, Vol. XIX, January–June, 1914, p. 79.

double the record annual output of the Royal Mint in London, and is believed to exceed the record of any Mint in the world. The activities of the Calcutta Mint have altered in recent years. Although the institution is responsible for supplying the whole demand for coinage in India, there is little coinage in the Silver Mint. The Copper Mint, however, is fully employed, and its output sometimes exceeds three-quarters of a million pieces in a day. A duty still undertaken by the Mint is the checking of weights and measures for the public. India possesses no standards of weights and measures; so the Mint keeps primary standards of iridio-platinum, and issues sets of standard weights when required.

Since 1929 the outstanding feature in the work of both the Indian Mints has been the export of gold consequent on Great Britain's departure from the Gold Standard. Enormous quantities of the precious metal have been brought to the Mints for melting and assay, the greater portion going to the Bombay Mint in which, during the year 1932–33, more than 140 tons were dealt with. The old saying, "Take care of the pence and the pounds will take care of themselves," is well understood by the Marwaris, to which thrifty race most of the bullion dealers of Calcutta belong. During the present export of gold, the Marwaris have been buying it everywhere, and bringing it to the Mint to be melted and assayed. A dealer will often bring in daily 1,000 *tolas*[1] (25 lb.) of gold, the value of which exceeds Rs. 30,000 (£2,000). In order to have his gold dealt with, he is required to submit, on the previous day, a requisition on the prescribed form. Now postage on an ordinary letter in India is fixed at $1\frac{1}{4}$ annas, but that on a small book-packet is only $\frac{1}{2}$-anna. Two bullion-dealers therefore decided not only to submit their requisitions by book post, but to enclose them together in one envelope. Thus each saved one anna. Can this be equalled in Aberdeen?

The Calcutta Mint assists in the prevention of counterfeiting. Among a population which is largely illiterate and scattered in remote districts, the counterfeiter plies his nefarious trade with profit. There are criminal tribes in India which have specialized in this work since the days of the Mughals, and the Mint authorities are constantly called upon to furnish expert evidence against them. A show-case in the Mint Museum bears the inscription "*Radix enim omnium malorum est cupiditas*," and displays specimens of counterfeit coins and the implements used in their manufacture. The patience of the counterfeiter and the manipulator of coinage is limitless. Government rupees have been found in which the interior has been abstracted, through a hole bored in the milled edge, and the cavity filled with cheap metal. The expert, however, is not content with tampering with Government coinage. He makes and issues his own.

[1] A *tola* = 180 grains (Troy), which is the weight of a rupee.

In unholy alliance with the counterfeiters of coin are the forgers of currency notes. Prior to 1861 there were no Government of India currency notes. Their first appearance in the country was in March, 1862. The notes were printed and issued by the Bank of England, which continued to supply them to India until about 1929. Within a few months of the first issue, several attempts at forgery were made by the process of altering 10-rupee notes into notes of a higher value. Notes were also copied by lithography. The water-mark was sometimes counterfeited by passing a brush, full of acid, across the paper. Occasionally, the water-marked paper of the Judicial Department was stolen, and notes were forged thereon. The simple design of the earliest specimens encouraged this form of crime, and even the issue of a new pattern in 1867–68 did not arrest it.

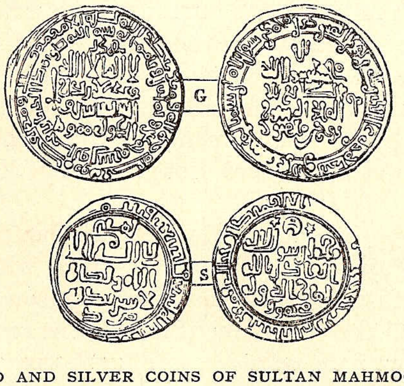
Only in recent years have military engineers taken any part in the production of Indian currency notes, though they were responsible until 1862 for the manufacture of postage stamps, which were printed by the Survey of India from plates made in the Calcutta Mint. In that year the printing of postage stamps was entrusted to a British firm, and it was the impending termination of this contract that induced the Government of India in 1923 to contemplate the printing, not only of stamps, but of currency notes when the Bank of England contract for the latter should expire. A decision was reached to build and equip a "Security Printing Press" at Nasik Road, 6 miles from Nasik and 120 miles from Bombay, to supply the whole of British India and Burma with postal and fiscal stamps, postal stationery such as postcards and embossed envelopes, security documents and cheques, and, in 1923, Lieut.-Colonel G. H. Willis, C.I.E., M.V.O., R.E., then Senior Mint Master at Calcutta, was placed on special duty for this purpose. The Security Printing Press was to be followed in due course by a Currency Note Press and a Central Stamp Store for the issue of the products of the Printing Press.

Colonel Willis carried the project through with conspicuous success. It was essential to locate the Security Printing Press near a main line of railway owing to the great weight and bulk of the stores received and issued. Before the onset of the present financial depression, the Press spent £125,000 annually on paper alone. Imagine the amount of paper which is represented by such a sum! It was necessary also that the site should be free from dust and dirt, and from great and sudden changes in humidity and temperature; that it should be near a military garrison; and that it should lie in a district where suitable labour was easily obtainable.[1] Many sites were considered, but the final choice fell on Nasik Road. The building of the Security Printing Press and the installation of its machinery were carried out during 1924 and 1925 at a cost of 27½

[1] *Report on Security Printing in India* (1923), by Lieut.-Colonel G. H. Willis, C.I.E., M.V.O., R.E., and Mr. F. D. Ascoli.

lakhs of rupees, and the Central Stamp Store followed at a cost of a further $8\frac{1}{2}$ lakhs. Then came the Currency Note Press, erected and equipped between 1926 and 1929 at a cost of 26 lakhs and capable of producing $1\frac{1}{2}$ millions of currency notes daily. While the Currency Note Press was under construction, Colonel Willis was assisted by Lieut.-Colonel H. J. Couchman, D.S.O., M.C., R.E. (now Surveyor-General) and by Major J. C. I. Wood, R.E.; and since its completion, Lieut.-Colonel W. E. Perry, M.C., R.E., Major C. G. W. S. Heaton-Armstrong, R.E., and Major D. Fitz J. Fitzmaurice, R.E. (retired), have shared in the administration and working of the presses. But the chief credit for the inception of the scheme, its execution, and its successful results should be accorded to Sir George Willis, who has served for more than 27 years with the Finance Department.

These Security Printing and Currency Note Presses cater for the postal, litigious and currency needs of some 350 millions of people. Their operations have resulted in an enormous reduction of expenditure. The whole capital cost of their construction and equipment has already been saved, and a large portion of the annual expenditure on their working is retained in the country. The 5,000 men, women and children, who form the community of workers and their families at Nasik Road, are well housed and supplied with every essential for their health and comfort. This is the latest achievement of a few of those military engineers who have rendered such good service in the Indian Mints.



GOLD AND SILVER COINS OF SULTAN MAHMOOD.

CHAPTER XVII.

POLITICAL, ADMINISTRATIVE AND FINANCIAL SERVICES.

IN the days of the East India Company, the surest and quickest road to fame and power lay through the Political Department. The military Political officer was welcome to the rulers of Indian States, for he carried with him the prestige of the Army. The prizes in this employment were dazzling : the life varied and full of interest; the authority, even at the outset, considerable ; the responsibilities easily shouldered. A gift for languages, a ready pen, and perhaps a relative in high office, were the chief requisites. Brains were desirable, but by no means essential. Subalterns of the infantry vied with each other to enter the golden portals of political service, if only to escape from drills and parades. Engineers were not so strongly attracted. They had other, and almost as promising, avenues of advancement in the civil line, and consequently they were far outnumbered in the Political Department by officers of the line.

Although many able and conscientious men—and among them, apparently, the sprinkling of military engineers—were to be found in the early days in the ranks of the " military politicals," there were some who were badly fitted for the posts which they held. Writing on the subject of the First Afghan War (1839–42), Sir John Fortescue remarks[1] that in India, at that time, an accomplished linguist was sure of promotion in either the administrative or diplomatic service. Any youthful subaltern who chose to spend his leisure hours in learning a new language was caught up, taken away from his military duties, and became what was called a " political." The field thus opened to enterprising young men was wide ; but the effect upon them of their sudden removal from military discipline was often pernicious.

In October, 1839, the young Resident at Quetta, a captain in the Army, ordered Major-General Nott to march with a small force to Kalat. Nott refused, giving adequate reasons. Thereupon the Resident informed the Government that " The responsible position I hold, and the power delegated to me, authorize my calling for the aid of troops to effect any measure that may appear to me to be of importance to the State." Thus did young political captains attempt to control the actions of generals. Nott did not mince his words. " Had I been allowed to have acted on my own judgment when Khelat fell into the hands of the rebels," he wrote in September,

[1] *History of the British Army*, by the Hon. Sir J. W. Fortescue, Vol. XII, pp. 15, 16.

1840,[1] "the fortress would now have been in my possession and the country in comparative quietness; but the authorities are never right, even by chance, and although most of them are stupid in the extreme, they fancy themselves great men and even possessed of abilities and talents. They drink their claret, draw large salaries, and go about with a numerous rabble at their heels. The Calcutta treasury is drained of its rupees, and good-natured Lord Auckland approves and confirms all. We are become hated by the people; and the English name and character, which two years ago stood so high and fair, has become a bye-word. This it is to employ men selected by intrigue and patronage! The conduct of the *one thousand and one* Politicals has ruined our cause and bared the throat of every European in this country to the sword and knife of the revengeful Affghan and bloody Beluch. Khelat is now taken, my hands are tied, and the whole country in rebellion."

Nott was a brave soldier of the old school, a strict disciplinarian, a veteran of many wars, and quick-tempered. No doubt he looked on the darkest side of the picture. Yet in 1863, Colonel Sir William Denison, late R.E., when acting as Viceroy and Governor-General, received a telegram from the political agent with General Chamberlain's army, then in the vortex of Ambela,[2] asking that the general should be directed to carry out whatever he, the aforesaid agent, might fancy or recommend. "These men," remarks Denison,[3] "very often officers of no high standing in the army, are apt to think that the possession of a small amount of local knowledge entitles them not only to express opinions on military matters, but also to control the action of the military authorities. They do not make the general in command acquainted with the facts which their position enables them to ascertain, but reasoning upon these, they strive to get practically the command of the force, while they repudiate the responsibility attaching to this."

Lieut.-General Sir George MacMunn, a distinguished soldier of modern times, points out that, because the avoidance of war rather than the discomfiture of foes is so often the prime object of our operations, political officers must accompany forces in the field; and that during the First Afghan War, as the recognized Political Service could not spare many men, the political staff in the field was largely drawn from young officers of the army.[4] The British Envoy, the chief Political Officer in that war, soon began to assume control of military movements, and the army authorities acquiesced. The envoy even detailed the troops. Young "politicals" led out forces commanded by much senior officers and often issued orders, their

[1] *Memoirs and Correspondence of Major-General Sir William Nott, G.C.B.*, edited by J. H. Stocqueler, Vol. I, pp. 255, 256.
[2] See Vol. I, Chapter XXI, pp. 425–428.
[3] *Varieties of Vice-Regal Life* (1870), by Sir W. Denison, K.C.B., Vol. II, p. 310.
[4] *Afghanistan from Darius to Amanullah*, by Lieut.-General Sir George MacMunn, K.C.B., K.C.S.I., D.S.O., p. 133.

ignorance and insistence being sometimes the causes of the military failures which occurred. Happily, all this has changed. Efficient and carefully selected military political officers are now attached to our armies in the field. They are admirably controlled, and work in harmony with their generals, who look to them for much of the information on which to base their strategy. The achievements of many political officers in the Second Afghan War were praiseworthy: in the Great War they were invaluable. The mistakes of the first campaign in Afghanistan will never be repeated.

In his valuable work entitled *Indian Polity*, published in 1870, Lieut.-Colonel (afterwards General Sir George) Chesney, Royal (Bengal) Engineers, made the following observations on the employment, in peacetime, of military officers in administrative and diplomatic posts in India:[1] "While in the four regulation[2] provinces—Bengal, Madras, Bombay and the North-West Provinces—all the superior district and administrative appointments are always filled by members of the covenanted[3] Civil Service, in other British territories—the Punjab, Oudh, the Central Provinces, Berar, and the native kingdom of Mysore—the governing staff consists of military officers as well as covenanted civilians. The same arrangement obtains in Assam and the other non-regulation parts of Bengal, as well as in the non-regulation province of Sind, which is under the Government of Bombay; while the official staff of Burmah is wholly composed of military officers. The services of the military officers thus employed in the civil administration of the country were formerly deemed to be lent temporarily only: the officers were always liable to be recalled to regimental duty on their units being ordered on active service, and they were also required to vacate their civil posts on attaining certain regimental ranks, unless they had already reached specified civil grades. It has now come to be regarded as a regular condition of every non-regulation province, except Burmah, that the official staff shall consist partly of civilians and partly of unattached military officers. There have not been wanting protests against the continuance of this system. The force of the English legal mind must sooner or later be brought to bear on the anomaly of appeals from the decisions of a captain of Infantry being heard by a major in the same service, and by him referred for final arbitration to a lieutenant-colonel of Engineers, sitting in appeal."

[1] Extracts from *Indian Polity*, by Lieut.-Colonel G. Chesney, R.(B.)E., pp. 240–247.

[2] Regulation provinces were those which were governed under regulations or acts framed, after 1853, by their Legislative Councils. Non-regulation provinces were administered by the orders of the Governor-General in Council.

[3] The covenanted Civil Service was so termed because each member of the service, before leaving England, entered into a covenant with the East India Company (afterwards with the Secretary of State for India) wherein his privileges were recited and he bound himself not to trade or receive presents, etc. The practice of binding the Company's servants by covenants not to accept irregular perquisites was introduced by Lord Clive in 1765.

"It need hardly be said," continues Chesney "that the mere possession of a military title does not, of itself, disqualify the holder from being an efficient magistrate or judge. The real question is whether, from the previous training of military officers, they are less likely to be efficient administrators than the men who go out to India direct in the Civil Service. It would appear that, under the old régime, the training of the military civilians was as least as regular and systematic as that of their brethren of the Civil Service. It may, however, be said that now, when the latter are chosen by competition and undergo a further preparatory course of special study, the case is different. The army forms virtually the only road to admission to Indian employment left open to the sons of Indian officials now that nomination to the Civil Service and to Indian cadetships has ceased. It has become an established practice to place them in the British Line, in view to their appointment to regiments serving in India, and eventually, through the medium of the Staff Corps, entering one or other of the numerous departments of the Indian administration. The real defect in the system of appointing military men to civil situations was to be found in the injury occasioned to the army by the inducements afforded to its best ability to seek a more lucrative field; while the extent to which this drain was carried, as the field of civil employment extended on the subjugation of the Punjab and subsequent annexations, denuded the regiments of the Indian armies of their officers to a dangerous degree. This defect has certainly been remedied by the new organization of 1861,[1] under which all officers on detached employment are borne on an Unattached List and cease to have any further connection with their regiments, promotions of effective officers being made in their place. But out of this arrangement arises the remarkable condition, now to be found, of a body of officers who are entitled to promotion, for length of service in purely civil duties, through the various army grades up to that of general officer."

Such were the general conditions, in war and peace, under which a few Engineer officers served in the olden days, alongside their brethren of the Infantry, in diplomatic or administrative employment; but with these important differences, that they do not seem to have been debarred from reverting for a time to their normal profession of engineering, and that they continued on the general list of promotion of their Corps. The Public Works Department was always ready for their reception. The political officers of the Line had no such additional field of civil employment.

In the space afforded by a single chapter it is impossible to describe in detail the careers of all the military engineers of India who devoted themselves to civil administration or diplomacy. It must suffice to select a few as examples of the remainder. Many officers, particularly

[1] See Vol. I, Chapter XIX, p. 369.

of the Survey of India, carried out political work, and wrote valuable reports to Government, as a normal supplement to their ordinary duties; but others were recognized political officers, and a few attained to the highest administrative posts. Although no military engineer has ever been appointed by the Crown as Viceroy and Governor-General of India, two have officiated in that exalted office. After the death of Lord Elgin in 1863, that famous soldier Major-General Sir Robert Napier, K.C.B., late Bengal Engineers, being then the senior (Military) Member of the Supreme Council, acted as Viceroy and Governor-General from November 21st to December 2nd, a period of eleven days. He handed over charge to another military engineer, Colonel Sir William T. Denison, K.C.B., late Royal Engineers, at that time Governor of Madras, and Denison officiated for nearly six weeks until Sir John Lawrence arrived on January 12th, 1864.[1] Several military engineers have been Governors or Lieutenant-Governors of provinces, and consequently deserve particular notice in these pages. Major-General Sir Archibald Campbell, K.B., late Madras Engineers, was Governor of Madras from 1786 to 1789, and Colonel Sir W. T. Denison from 1861 to 1866. Major-General Sir H. M. Durand, K.C.S.I., C.B., late Royal (Bengal) Engineers, was Lieutenant-Governor of the Punjab in 1870; and Colonel Sir George Sydenham Clarke, G.C.M.G., G.C.I.E., late Royal Engineers, was Governor of Bombay from 1907 to 1913. British Baluchistan has had its Engineer administrators. From 1892 to 1896, Major-General Sir James ("Buster") Browne, K.C.S.I., C.B., late Royal (Bengal) Engineers, was its Chief Commissioner. Colonel O. B. C. St. John, C.S.I., of the same Corps, officiated as such for six months in 1887, and General Sir H. N. D. Prendergast, V.C., K.C.B., late Madras Engineers, for a similar period in 1889. Archibald Campbell, Henry Durand, William Denison, James Browne and George Clarke can justly be considered the most eminent "Engineer-Politicals" of India. At least they are typical of their brother politicals, and their combined activities cover a wide period of Indian history.

When Sir William Denison was Lieutenant-Governor of Tasmania in 1852, he wrote[2]: "The people of the adjoining colonies are beginning to find out the advantage of having an officer of the Engineers as Governor. I have had references from Sydney, Melbourne and Adelaide applying for my advice on the construction of docks, the supply of water, the construction of canals, and the formation of a harbour." Denison's tenure in India, and those of the other Governors who were Engineers, were marked by the greatest energy, not only in engineering, but in measures for the welfare of the people. The meticulous regard for accuracy, and the attention to detail,

[1] Sir William Denison officiated as Viceroy and Governor-General under the Act of 1861, which provided that, in the absence of the permanent incumbent of the post, the senior of the Governors of Madras or Bombay should officiate.

[2] *Varieties of Vice-Regal Life*, by Sir W. Denison, K.C.B., Vol. I, p. 194.

which are prominent characteristics of the military engineer, have their value in civil administration, even though they may lessen to some extent the breadth of outlook. The engineer is essentially practical. May he ever remain so!

The early career of Major-General Sir Archibald Campbell, K.B., the first military engineer to be appointed Governor of an Indian province, was most adventurous.[1] Commissioned on February 8th, 1758, as a Practitioner Engineer and Ensign in the Corps of Engineers of the King's Army, he was employed during the next four years in three expeditions to France, and in the West Indies at the capture of Guadeloupe, Dominica and other islands. In 1764, when a Captain-Lieutenant and only 25 years of age, he was selected to be Chief Engineer in Bengal, but apparently did not voyage eastwards until 1768 when he was promoted to the rank of Lieut.-Colonel in the Bengal Engineers.[2] Extensive fortification was then in hand, not only at Fort William in Calcutta, but at Bombay and at Fort St. George in Madras. The outworks of Fort William were not progressing properly under the ultra-economical direction of Lieut.-Colonel Fleming Martin:[3] in Bombay, Lieut.-Colonel Thomas Keating was engulfed in an endless dispute about the fortification of Dongri Hill:[4] in Madras, Lieut.-Colonel John Call was labouring under great difficulties to render Fort St. George sufficiently strong to resist the power of Mysore.[5] A guiding hand was needed, and accordingly Archibald Campbell was sent to India to relieve Fleming and expedite the completion of Fort William, and also to advise the Chief Engineers of Bombay and Madras. He carried out his duties with marked ability, but resigned his appointment in 1772 because, under certain new rules, he would have had to relinquish his King's commission if he had remained in the service of the East India Company. On his homeward voyage in the following year he inspected the Madras defences at the invitation of his friend Lieut.-Colonel Patrick Ross, M.E., then Chief Engineer, and thereafter severed his connection with engineering. He was ambitious, rich, adventurous. He aimed high and in due course attained his ambition.

Within two years of his return to England, Archibald Campbell entered Parliament. Then came the American rebellion, when he raised the 71st Regiment of Highlanders at his own expense and led them across the ocean only to be overwhelmed and captured in a desperate naval action off Boston in June, 1776. After two years in captivity he was released and took command of the troops in Georgia. Before the close of 1778 he was appointed Lieutenant-Governor of Jamaica and, in 1780, Captain-General and Governor-in-Chief of that

[1] A portrait of Sir Archibald Campbell appears opposite page 134 in Vol. I, and a brief synopsis of his career is given in a footnote on page 133 of that volume.

[2] Court to Bombay, letter dated March 18th, 1768. *Public Department Court's Letters*, Vol. VII, of 1765–68.

[3] See Vol. I, p. 133. [4] *Ibid.*, pp. 96, 97. [5] *Ibid.*, pp. 80, 81.

island. So successful was his conduct of affairs that he was made a Knight of the Bath, and in 1785 was chosen to be Governor of Madras, thus returning in a political capacity to the land in which he had already established a reputation as an engineer. He assumed office as Governor and Commander-in-Chief on April 6th, 1786, and began a brilliant administration which lasted until February 6th, 1789.

In his dual capacity Major-General Sir Archibald Campbell was called upon to protect a weak and extensive frontier, to reorganize the Madras army, and to provide resources in a country devastated by war. "Skilled in every branch of military science, with knowledge matured by experience in various countries and climates, indefatigable in all public duties, and endued with a degree of worth and benevolence which attached him to all ranks of the army, he had a task to perform which, though great and complicated, was not beyond the reach of such distinguished talents."[1] Fortunately, Campbell's work of reformation was undisturbed by hostilities, and so he was enabled to make rapid progress, not only in the reorganization of the army, but in the development of peaceful institutions. He formed a Military Board, a Hospital Board, a Board of Revenue, a Board of Trade and a Committee of Police. He established the Madras Exchange and the Carnatic Bank, secured a great increase in revenues, and arranged for the reduction of the outstanding debt. He built huge granaries throughout the Carnatic to guard against the exigencies of war or famine. He completed a train of heavy and light artillery, and camp equipage for an army of 20,000 men; he repaired and re-armed many forts, strengthened the cavalry, and improved the discipline of the troops. Such energy in one whose health had been impaired by the hardships of captivity could not be maintained. Illness overtook him, its onset being accelerated no doubt by dissensions between him and Lord Cornwallis, the Governor-General. As a result, Campbell resigned his appointment and sailed for England in February, 1789. After his death in London, on March 31st, 1791, he was accorded an honoured resting-place in Westminster Abbey. His administrative career in Madras was short, but his reforms were far-reaching and valuable. The first Engineer-Governor in India acquitted himself well and added to the reputation of his Corps.[2]

Engineers reappeared in the political field shortly before the First Afghan War. From that time up to the end of the Indian Mutiny the names of H. M. Durand, E. J. Brown, J. D. Cunningham, J. R. Becher, E. J. Lake and R. Young, all of the Bengal Engineers, recur in the records as assistants to Commissioners of districts or Residents

[1] *Narrative of the Campaign in India*, by Major Dirom (1793).

[2] Memoirs of Major-General Sir Archibald Campbell, K.B., late B.E., appear in *History of the Corps of Royal Engineers*, by Major-General W. Porter, Vol. II, pp. 397–400; in *Vestiges of Old Madras*, by Colonel H. D. Love, Vol. III, pp. 319–321; and in *The Royal* (*Bengal*) *Engineers*, by Colonel Sir E. T. Thackeray, V.C., K.C.B., pp. 7–11.

in native states, and latterly as full-fledged Commissioners or Residents. Most of the Engineer-Politicals of this period were to be found in northern India, where the services of soldiers were more valuable for political work than in the peaceful south. Conspicuous among his contemporaries was Captain George Broadfoot, a Madras infantryman whom engineers claim as one of themselves in virtue of his brilliant leadership of the six companies of "Broadfoot's Sappers" which he raised for service in the First Afghan War.[1] Broadfoot's exploits in Afghanistan, and particularly his defence of Jalalabad under General Sale,[2] brought him to the notice of Lord Ellenborough, and in 1842 he became Commissioner of the Tenasserim Provinces of Lower Burma. In 1844, however, he was transferred to the responsible post of Political Agent of the North-West Frontier, then on the Sutlej, and was followed in Tenasserim by Henry Durand. The latter arrived unexpectedly, and Broadfoot, who had passed through a stormy time in Burma, thought at first that matters had gone against him. "Well, Durand," he said, "what brings you here?" "I have come to relieve you," replied Durand. "The devil you have!" exclaimed Broadfoot. "Why, what is the matter?" Explanations followed, and Broadfoot was delighted to learn, for the first time, of his transfer to the finest political appointment in India.[3] He assumed charge at Ambala, the frontier base, on November 1st. Beyond lay the Sikh kingdom of the Punjab.

Sad to say, George Broadfoot was killed during the First Sikh War at the battle of Ferozeshah, on December 21st, 1845.[4] A memorial in Madras is inscribed with his epitaph. "*Per Ardua Virtus*," it runs. "Sacred to the memory of Major George Broadfoot, C.B., 34th Madras Light Infantry, of Kirkwall, in the Orkneys, and of London. His valour, foresight and science mainly contributed to the success of the glorious defence of Jellalabad; and in the ensuing Afghan Campaign he, with his brave Corps of mountain Sappers, acquired enduring renown. His diplomatic and military services, as Commissioner of the Tenasserim Provinces and as Governor-General's Agent on the North-Western Frontier, at a most important crisis, called for the eloquent eulogy of Sir Henry Hardinge that he was as brave as he was able, and second to none in all the great qualities of an accomplished officer. . . . His loss was recorded as a public calamity in both Houses of Parliament. He was the last of three brothers who died for their country on the battlefields of Asia."[5] A fitting tribute to a remarkable personality.

[1] See Vol. I, Chapter XV, p. 275.
[2] *Ibid.*, Chapter XV, pp. 277, 278.
[3] *The Life of Major-General Sir Henry Marion Durand, K.C.S.I., C.B.*, by H. Mortimer Durand, Vol. I, p. 90.
[4] See Vol. I, Chapter XVI, p. 294.
[5] *The Career of Major George Broadfoot, C.B.*, by Major W. Broadfoot, R.E., p. 427. The youngest brother, Lieutenant James S. Broadfoot, B.E., was killed near Kabul, in November, 1840, and the second, William, of the Bengal Infantry, in Kabul a year later. (See Vol. I, Chapter XV, pp. 272, 275.)

Perhaps the most celebrated of the military engineers of India who adopted the political line was Major-General Sir Henry Marion Durand, K.C.S.I., C.B., known as "Durand of Ghazni," on account of the leading part which he took in blowing in the Kabul Gate of that Afghan stronghold on July 23rd, 1839.[1] Durand obtained a commission in the Bengal Engineers in June, 1828, but did not reach India until May, 1830. After spending several years in the Irrigation Department on the Western Jumna canals and on other civil work, he reverted to military duty for the First Afghan War, in which he acquitted himself well. While on furlough in England after that war, he was selected by Lord Ellenborough, the newly-appointed Governor-General, to accompany him to India as an aide-de-camp, and from 1842 to 1844 he filled the post of Private Secretary. So far, he had gone from strength to strength. His foot was firmly set on the lowest rung of the political ladder, and, as already related, he was appointed in 1844 to succeed George Broadfoot as Commissioner of the Tenasserim Provinces.

But Durand was a man of blunt speech and strong will. He spoke and acted with such extreme vigour, regardless of the consequences, that he made many enemies. However, with the support of Lord Hardinge, who had replaced Ellenborough, he did much for Tenasserim by reducing military expenditure, checking the aggressive tendencies of the Mandalay Government, and introducing a new system of land assessment. The administrative scheme which he set in operation was, in fact, the germ of the famous "non-regulation" system, which was applied afterwards in the Punjab and elsewhere. A new judicial system, which he evolved, was found to be simple and efficient. But during the summer of 1845 Lord Hardinge was obliged to leave Calcutta for the north-west, because the aspect of affairs on the Sikh frontier was most threatening, and as soon as his back was turned, Durand was assailed by enemies. Everywhere he encountered opposition and censure, and this year was for him the beginning of a long course of disappointment which embittered the rest of his life. He was recalled to Calcutta in 1846, and proceeded on furlough in the following year after refusing to accept an appointment as Chief Engineer in the Punjab which Lord Hardinge had offered to him. Durand's first essay as an administrator had ended in disaster. "The spirit of hostility towards you here," wrote a friend in Calcutta, "is so inveterate and desperate as to amount to a perfect mania."[2]

Returning to military duty in India in 1848, Durand fought against the Sikhs in the battles of Chilianwala and Gujarat[3], and when the

[1] See Vol. I, Chapter XV, pp. 272, 273. Henry Marion Durand was the father of Sir Henry Mortimer Durand, G.C.M.G., K.C.S.I., K.C.I.E., I.C.S., the originator of the "Durand Line" along the Afghan frontier.

[2] *The Life of Major-General Sir H. M. Durand, K.C.S.I., C.B.*, by H. M. Durand, C.S.I., Vol. I, p. 101.

[3] See Vol. I, Chapter XV, pp. 305, 306.

MAJOR-GENERAL SIR H. M. DURAND, K.C.S.I., C.B.,
LATE ROYAL (BENGAL) ENGINEERS.

Punjab had been annexed, applied to Lord Dalhousie for a political appointment in that territory. In reply he was offered nothing better than a deputy commissionership, with authority over a single district. This he refused, and consequently offended Dalhousie; but nevertheless he accepted a temporary post as Assistant Resident at Gwalior in May, 1849. "Think of the retrograde promotion," he writes. "I am now *an acting assistant!* However, I was determined not to offend by making a second refusal, so I came here, the vilest, hottest place that can be conceived." From Gwalior he was transferred as Political Agent to Bhopal, where he remained for the next three years. After another furlough in England, he was posted at the end of 1855 as Superintending Engineer in Calcutta, a fact which seemed to indicate that his political career was at an end. From Lord Dalhousie he expected nothing and received nothing; but fortunately, through the sound advice which he was able to give on matters connected with Baluchistan and Persia, he gained the good opinion of Lord Canning in 1856, and as a result was offered and accepted the appointment of Political Agent at Indore, where he assumed office in April, 1857. The turning-point in his career had come. The Central Indian Agency was one of the three most important charges in India, the others being the Agencies of Rajputana and Hyderabad. Twelve large states and many small ones were included in Central India, and the Agent at Indore exercised virtual control over 86,000 square miles of territory, populated by eight millions. The history of Durand's tenure at Indore is the history of the Indian Mutiny south of the Jumna. The Mutiny broke many men: it made Durand.

On arrival in Central India, Durand took immediate steps to meet the rebellion which he foresaw. With the exception of one battery of artillery, he had no British troops. For six weeks after the outbreaks at Meerut and Delhi he succeeded in maintaining order by isolating the Native States' contingents and playing them off against the regulars; but when, contrary to his wishes, the two were allowed to come into contact, the fidelity of the contingents gave way. On July 1st, 1857, Holkar's troops rose and attacked the Indore Residency, from which, driven out by the treachery or cowardice of his Indian supporters, Durand made a masterly retreat north-eastwards to Sehore, veiling his weakness by a show of force. Thence he proceeded to Hoshangabad, and resolutely holding, in spite of orders to the contrary, the natural barrier of the Narbada, he pushed a column under General Woodburn up to Mhow. Then, using that column, now under General Stuart, as a compact and mobile force, he captured the fortress of Dhar, gained three victories in the field, took more than forty guns, and dispersed or disarmed rebel concentrations which far outnumbered his own. The operations in Malwa paved the way for the brilliant campaign under Major-General Sir Hugh

Rose which extinguished the last embers of the Mutiny ;[1] but when Durand relinquished the charge of the Central Indian Agency on December 16th, he had already safeguarded British interests in that part of the peninsula and had reinstated himself in the estimation of the Government.

From Indore, Durand went to Bombay and Calcutta and, at the end of April, 1858, he was deputed to England to represent the views of the Government of India on the reorganization of the Indian Army. He was nominated in 1859 to a seat on the newly-formed Council of the Secretary of State ; and early in 1861, when the " battle of the Staff Corps " was over, he was offered by Lord Canning the Foreign Secretaryship of India, which he filled with success during the next four years. His work at the Foreign Office was varied and full of interest, comprising, as it did, the control of our relations with feudatory states, diplomatic dealings with neighbouring foreign powers, and the management of all ceremonial arrangements. Durand disliked the sweeping annexations of Lord Dalhousie, and was well suited to carry out the conciliatory measures of Lord Canning, which stilled the troubled waters left by the Indian Mutiny. He was an authority on India in general, and on the Indian States in particular, and he spoke several Eastern languages. At the outset his appointment was viewed with some jealousy by the Indian Civil Service ; but its members soon recognized that a wise choice had been made. While Foreign Secretary, Durand refused tempting offers of the Chief Commissionership of Mysore and the Residency of Hyderabad. He did not relinquish his post until 1865, when he succeeded Major-General Sir Robert Napier as Military Member of the Viceroy's Council[2] and so remained for the next five years.

On May 5th, 1870, Durand received the highest honour of his career in the form of a telegram from Lord Mayo offering him the Lieutenant-Governorship of the Punjab, a territory as large as Italy. This, of course, he immediately accepted. No more important or responsible post, except that of Viceroy, was available, or is still available, in India. On June 1st, Durand took the oath at Murree. His reputation for ability, experience, high principles and force of character was then unsurpassed between the Himalayas and Cape Comorin. It seemed that a long and successful administration lay before him. But it was not to be. At dusk on December 31st he was riding on an elephant through a gateway leading into the town of Tank near the Mahsud border. The gateway was low ; the *mahout* inexperienced ; the elephant restive. Crashing into the roof, the *howdah* was swept off, and Durand fell backwards to the ground. He was picked up unconscious and partly paralysed and, a few hours later, passed away. So ended, by a miserable accident,

[1] See Vol. I, Chapter XVIII, pp. 363–367.
[2] Sir Robert Napier had been appointed Commander-in-Chief in Bombay.

the brilliant career of a military engineer who was both soldier and statesman.[1]

Among the pre-Mutiny political officers less famous than Durand was Joseph D. Cunningham, a Bengal Engineer who was the elder brother of Alexander Cunningham of the same Corps. Joseph was selected in 1837 to be Assistant Political Agent on the Sikh frontier, an appointment which enabled him, during the next eight years, to study the manners and customs of a warlike people, and so to publish in 1849 his valuable *History of the Sikhs*. He served as a political officer in both the First Afghan and First Sikh Wars,[2] and, on the conclusion of the latter campaign, was sent as Political Agent to Bhopal. He was thus singularly fortunate for so young an officer, for he was then only 33 years of age. But his literary pursuits were his undoing. In Cunningham's *History of the Sikhs* Lord Dalhousie found certain passages which he considered as criticisms of his policy. The author was at once removed from his post, and died, some say of a broken heart, in February, 1851.[3] Another Bengal Engineer who served in the Afghan and First Sikh Wars, though in a military capacity, was John R. Becher,[4] seven years junior to Cunningham. Becher embarked on a political career in Rajputana and the Punjab in 1847, was Commissioner of Hazara from 1853 to 1859, of the Derajat from 1862 to 1864, and then of Peshawar until 1866, when he retired through ill-health. He was one of the distinguished group of officers employed in the Punjab after its annexation in 1849, and it is said that he was much loved and respected. He attained the rank of General before his death in 1884.[5] While Becher was in Hazara, Lieutenant (afterwards Colonel Sir Henry) Yule, B.E., accompanied Sir Arthur Phayre as Secretary of the Embassy to the King of Burma which visited that country in 1855–56. Although Yule's labours were cut short by the Indian Mutiny, he produced most interesting reports, illustrated by clever sketches, and afterwards published his well-known volume, *A Mission to the Court of Ava*.[6]

Among other military political officers who joined the Engineer Corps before the Indian Mutiny may be mentioned Major-General

[1] Memoirs of Major-General Sir H. M. Durand appear in *The Life of Major-General Sir Henry Marion Durand, K.C.S.I., C.B.*, by H. M. Durand, two vols. (1883); in *History of the Corps of Royal Engineers*, by Major-General W. Porter, Vol. II, pp. 489–493; in *The Royal (Bengal) Engineers*, by Colonel Sir E. T. Thackeray, V.C., K.C.B., pp. 130–158; and in *Addiscombe. Its Heroes and Men of Note*, by H. M. Vibart, pp. 431–438.

[2] See Vol. I, Chapter XV, pp. 272, 294.

[3] Memoirs of Captain J. D. Cunningham, B.E., appear in *The Royal (Bengal) Engineers*, by Colonel Sir E. T. Thackeray, V.C., K.C.B., pp. 40–48; and in *Addiscombe. Its Heroes and Men of Note*, by H. M. Vibart, pp. 453–455.

[4] See Vol. I, Chapter XV, p. 278.

[5] A memoir of General J. R. Becher, C.B., late R.(B.)E., appears in *Addiscombe. Its Heroes and Men of Note*, by H. M. Vibart, pp. 474–478.

[6] Memoirs of Colonel Sir Henry Yule, K.C.S.I., C.B., late R.(B.)E., appear in a volume by A. F. Yule; in *History of the Corps of Royal Engineers*, by Major-General W. Porter, Vol. III, pp. 267–270; and in *Addiscombe. Its Heroes and Men of Note*, by H. M. Vibart, pp. 487–490. Yule was for nearly 14 years a member of the Council of the Secretary of State for India, and made a great reputation as a scholar.

Edward J. Lake, C.S.I., late Royal (Bengal) Engineers, and General Sir Harry N. D. Prendergast, V.C., K.C.B., late Royal (Madras) Engineers. Lake was commissioned in 1840, and took part in the First and Second Sikh Wars, including the siege of Multan. Under Herbert Edwardes, in 1848, he led the Bahawalpur levies against the rebel Mulraj. But his claim to celebrity lies chiefly in his civil work as Commissioner of Jullundur from 1855 to 1860, and as Financial Commissioner of the Punjab from 1865 to 1867. Lake was one of the few men who are almost equally fitted for military or civil duties—a soldier-civilian who was a tower of strength to the administration to which he belonged. Lord Lawrence remarked that if Lake's health had stood the wear and tear of continuous hard work in civil employment he might have risen to be Lieutenant-Governor of the Punjab; but frail in body, though great in spirit, he was obliged to retire in 1870 and died in England seven years later.[1] Prendergast, already celebrated as a soldier, adopted a political career after his successful command of our troops in the Third Burma War.[2] In 1887 he was Officiating Resident in Travancore and Cochin, and also in Mysore. Two years later he officiated as Political Agent in Baluchistan, and in 1891–92 once again as Resident in Mysore after the death of Colonel Sir Oliver St. John, K.C.S.I., late R.(B.)E., a man of marked ability who had occupied that and other posts, and had been Political Officer in the Kandahar theatre during the Second Afghan War.[3] Prendergast had administered the whole of Burma after King Thibaw capitulated, and this experience stood him in good stead in India. He served his country ably in a new capacity until the date of his retirement.[4] Mention may be made also of a Bengal Engineer who was once a Political Officer, but afterwards launched out into a novel employment. Major-General George Hutchinson, C.B., C.S.I., when a subaltern, acted as a Political Officer during the Indian Mutiny, and helped to defend the Residency at Lucknow.[5] In 1861, however, while only a Major, he was selected by Sir Robert Montgomery to form and organize a Punjab Police Force, and he held the appointment of Inspector-General of Police until he retired as a Major-General in 1876.[6] It can truly be said that there is hardly a department of the civil administration in India in which military engineers have not appeared.

[1] Memoirs of Major-General Edward J. Lake, C.S.I., late R.(B.)E., appear in *The R.E. Journal*, Vol. 7, 1877, p. 54; in a pamphlet entitled *In Memoriam. Major-General Edward Lake* (1878); and in *Addiscombe. Its Heroes and Men of Note*, by H. M. Vibart, pp. 503–505.

[2] See Vol. I, Chapter XX, pp. 406–409.

[3] *Ibid.*, Chapter XIX, pp. 375, 382, 388.

[4] Memoirs of General Sir H. N. D. Prendergast, V.C., K.C.B., appear in *The R.E. Journal*, Vol. XVIII, 1913, pp. 241–242, and in *Addiscombe. Its Heroes and Men of Note*, by H. M. Vibart, pp. 614–625.

[5] See Vol. I, Chapter XVIII, pp. 351, 353.

[6] Memoirs of Major-General G. Hutchinson, C.B., C.S.I., R.(B.)E., appear in *The R.E. Journal*, April, 1900, and in *Addiscombe. Its Heroes and Men of Note*, by H. M. Vibart, pp. 549–554.

Fifty years ago, the life of the Indian civil servant, whether Political Officer, Commissioner or Resident, though overburdened with care and responsibility, had its amusing interludes. Sir Walter Lawrence records[1] that he once received a letter from an Indian clerk which opened with the surprising words " Spanking Sir," so he sent for the clerk and asked for an explanation. The man then produced, with great pride, a copy of *Letters from a Gentleman in Town to a Young Friend in the Country*, in which occurred the passage, " thanks to industry and assiduity I am now in a position to drive a pair of spanking steeds." Another applicant made the shocking announcement that his mother was " tight " (Hindustani *tang*)[2] meaning only that she was poor. Yet another described a rival most aptly as a " flickering fellow." The daily mail of the hard-worked political officer often yielded such gems, concealed amid ponderous despatches and memoranda.

Most of the military engineers who served the Government of India in a political or administrative capacity were East India Company's officers, but occasionally a Royal Engineer was selected for high office. Among the latter, one of the most notable was Lieut.-General Sir William T. Denison, K.C.B., who, though commissioned in 1826, did not make his first acquaintance with India until 1861, when he was a Colonel. Up to 1846 he was employed on canal construction in Canada, as an Instructor in Surveying at Chatham, on astronomical work under the Ordnance Survey, and finally, for a period of nine years, on engineering work in the Admiralty dockyards. Then came a sudden change of environment and duties. Denison, while still a Captain, was knighted and appointed Lieutenant-Governor of Tasmania (Van Diemen's Land). So successful was his rule in that island that in 1854 he passed on to be Governor of New South Wales and titular Governor-General of Australia, and so remained for the next six years. This was the experienced administrator who, on February 18th, 1861, was appointed Governor of Madras, and held that office until March 27th, 1866, including (as already noted) a period of six weeks during which he acted as Viceroy and Governor-General of India. As an authority on railways, roads and other public works, his services as Governor were particularly valuable while India was recovering from the dislocation caused by the Mutiny.

In ordinary circumstances a man with political experience only as a Colonial Governor would find much requiring thought and study before he could hope to succeed in India ; but in 1861 the situation was complicated by the changed relationship between the people and the Government, due to the abolition of the East India Company in 1858, and the assumption of control by the Crown. Government

[1] *The India We Served*, by Sir W. R. Lawrence, Bart., G.C.I.E., G.C.V.O., C.B.
[2] Tightly fastened, restricted.

was in an experimental state. Each provincial Governor had unusual responsibilities thrust upon him and, under circumstances without a parallel in history, he had to ascertain the existing state of affairs and also to foresee its probable results. Sir William Denison set himself first to curtail military expenditure and to reduce the strength of the Madras Army. In these military projects he was successful, and also in encouraging engineering development; but he encountered serious difficulties in his relations with a section of the people, and particularly with his newly-formed Legislative Council. He did not conceal his unfavourable estimate of the Indian character, and he strenuously opposed the admission of Indians into the Council. In modern slang parlance, Denison was a "die-hard." He wished to have a free hand; he had no desire to teach the art of governing; he abhorred long discussion; he was pre-eminently a man of action. But whether, under the conditions then obtaining, he was right or wrong, it is certain that the Madras Presidency benefited by his disinterested rule.

Sir William Denison will always be remembered for his wise handling of the critical situation at Ambela during the period of six weeks when he was acting as Viceroy and Governor-General. Certain Muhammadan fanatics known as Wahabis, reinforced by other turbulent characters on the North-West frontier, had been driven from Sittana[1] in 1858, and, establishing themselves at Malka in 1861, became a menace to the Punjab. Under the direction of the Punjab Government, Major-General Sir Neville Chamberlain was sent against them in 1863 with some 5,000 men and was soon in dire straits on the Ambela Pass, almost surrounded by 15,000 Bunerwals and Swatis who had treacherously risen against him.[2] For three weeks his advance was checked and he was on the defensive. The Calcutta Council, greatly alarmed, contemplated the disastrous course of recalling the expedition, a confession of weakness which might have set the whole frontier ablaze. Then Denison appeared on the scene. "I could not but think," he writes,[3] "that the Commander-in-Chief [General Sir Hugh Rose] had been improperly kept in ignorance of the steps which it was proposed to take. The most startling fact of all was the morbid fear which seemed to have influenced the Government of the Punjab and the Military Secretary to the Government of India, making the one propose, and the other recommend, the withdrawal of the troops; while the members of the Council at Calcutta, partaking of, or influenced by, this alarm on the part of the originators of the movement against the tribes, had backed up the recommendation by a statement to the Commander-in-Chief that the object of the Government was to withdraw the troops as soon as it could be done without loss or discredit. . . . I

[1] On the Indus, north-east of Attock. See Map III.
[2] See Vol. I, Chapter XXI, pp. 425–428.
[3] *Varieties of Vice-Regal Life*, by Sir W. Denison, K.C.B., Vol. II, pp. 299, 300.

therefore made up my mind at once to press upon the members of Council the advisability of reversing the order given to the Commander-in-Chief and, should they not do so, to act on my own authority and direct the Commander-in-Chief to make a forward instead of a retrograde movement."

The determination shown by Denison induced the Council to withdraw the order for retirement and to substitute instructions for an advance. The result was that two days' fighting at Ambela finished the campaign, cowed the mountaineers, and restored British prestige. Denison then tried to drive home a lesson taught by the "Spectre of Ambela" which he had laid. "I brought strongly before the Secretary of State," he says,[1] "the impolicy of leaving the command of local corps, such as the Punjaub Irregular Force[2] and the Nizam's contingent, in the hands of civilians. Lord Elgin found that the control of the Punjaub Force made the Lieutenant-Governor there, to a certain extent, independent of the Governor-General. He had the power of so employing his force as to bring about a state of things which compelled the supreme Government to act in a manner the very reverse of that which a sound policy would have dictated." In due course the necessary reform was made, and the position of the Commander-in-Chief was thereby strengthened.

Sir William Denison left India in 1866 and returned to England, where he, who had acted as Viceroy, was offered and actually accepted the humble position of Commanding Royal Engineer at Portsmouth. However, he was not allowed to take up his new duties, because the Inspector-General of Fortifications considered that it would be improper to employ him in such a post after the high positions he had held. So the ex-Viceroy and Provincial Governor was made Chairman of a Royal Commission for the prevention of pollution of rivers, a curious post which he held till his death in January, 1871. The career of Sir William Denison illustrates in vivid fashion the extraordinary and violent changes of employment which fall so often to the lot of a Royal Engineer.[3]

The achievements of Major-General Sir James Browne, K.C.S.I., C.B., late Royal (Bengal) Engineers, as a soldier, an engineer, and a political officer, are worthy of record in any history of India. "Buster" Browne, as he was called, was a man in a thousand. Capable, energetic, brave, full of human sympathy, popular with his own countrymen, and adored by the wild Pathans of the North-West Frontier, he was an ideal builder of empire. Commissioned in December, 1857, he saw nothing of the Indian Mutiny; but he fought

[1] *Varieties of Vice-Regal Life*, by Sir W. Denison, K.C.B., Vol. II, p. 311.

[2] See Vol. I, Chapter XIX, p. 395, footnote. The "Punjab Irregular Force" afterwards became the "Punjab Frontier Force" which was abolished in 1906.

[3] A memoir of Lieut.-General Sir William T. Denison, K.C.B., late R.E., appears in *History of the Corps of Royal Engineers*, by Major-General W. Porter, Vol. II, pp. 466–471.

against the Mahsud Waziris in 1860, and thus made his first appearance in those forbidding and desolate regions where his life's work was to lie. Afterwards, under Alexander Taylor, he built the Grand Trunk Road from Attock to Peshawar,[1] meeting the tribesmen on friendly ground, and in 1863 fought against them at Ambela.[2] Returning to civil engineering, he developed into an expert in mountain road-construction and the designing of iron bridges for roads and railways. In this capacity he left his mark both on the frontier and in the Kangra district. Along 450 miles of the Afghan border from Hazara to Sind, roads, bridges, churches, barracks and other buildings, forts and batteries, river embankments and tunnels, showed his skill and vigour. While on the frontier he practically lived with the Pathans. Far from British stations, and often without a tent, he slept in native huts, ate with the tribesmen, conversed freely with them in their own language, became friendly with their headmen, and was passed on by them from village to village. He identified himself with the people to such an extent that, when he was sent in 1876 to survey a line of railway from Sukkur to Quetta, he was able to serve the Government in a capacity even more important than that of engineer.

Although " Buster " Browne's influence with the Pathan tribes was largely due to his character and conduct, it was strengthened by a curious belief among the tribesmen that he was actually one of their own Mullas, or holy men, in disguise. History records that Browne had a " double," a mysterious individual, said to be a young British officer, who had crossed the frontier disguised as a Mulla and, assuming the name of " Ismail Ali," journeyed with a caravan to Constantinople, visited Mecca and finally returned to Afghanistan, where he married and settled down in 1870.[3] In course of time, " Ismail Ali, the Mulla of Mukkur," became well known to the Pathans and Ghilzais travelling to the Quetta frontier ; and these men, seeing Browne in that neighbourhood, were much struck by his close resemblance to the Mulla. They knew that the Amir of Afghanistan employed Ismail Ali to report on the British movements in the Kandahar region, and in 1876 they began to assert openly that Browne was no other than Ismail. The result was of remarkable political value. Browne was able to move freely and in perfect safety amid the swarms of fanatics who infested the frontier. The machinations of Russia, especially with the Amir, necessitated vigorous action on the part of the British, and Browne began to keep a close watch on the situation. Privileged as he was through his resemblance to Ismail, he became indispensable as a collector of

[1] See Chapter IV, " Northern Roads," pp. 64-68.

[2] See Vol. I, Chapter XXI, p. 428. References to " Buster " Browne appear also on pp. 375, 382, 387 (footnote), 402, and 511 (footnote) of that volume, and in Chapter IX, (pp. 144-152) of this volume in which his portrait is included.

[3] *The Life and Times of General Sir James Browne, R.E., K.C.S.I., C.B.* (*Buster Browne*), by General J. J. McLeod Innes, V.C., C.B., late R.(B.)E., p. 150.

information. The political eye lighted on him. The golden gates began to open.

In 1877, "Buster" Browne submitted a railway report which displayed such an intimate knowledge, not only of technical matters, but of the general situation, that he was summoned to Simla to consult with the Viceroy, and was afterwards selected for special employment under the Foreign Office to keep the Government informed regarding the state of feeling among the tribes of the Pishin border, and to use his influence to prevent them from siding with Afghanistan in case of war. With the help and support of Colonel (afterwards Sir Robert) Sandeman, the Governor-General's Agent in Baluchistan, Browne filled his new post with conspicuous success, aided perhaps by the spreading rumour that he was the holy Ismail Ali in another guise. But the real Ismail Ali, the Englishman turned native, was beginning to find that his position in Afghanistan was precarious and even dangerous, although he carried out the Amir's instructions in making at least two journeys from Kabul to Quetta, where he was once seen in Afghan dress and questioned by Browne. Then, in 1878, he slipped away to Karachi and Bombay, and so vanished. Who was he ? Whence did he come ? Whither did he go ? No one knows. The Ghilzais and other frontier tribes certainly saw him no more ; but they met Browne daily at Quetta, and so were confirmed in their belief that he was Ismail Ali, the ex-Mulla, an idea which they continued to hold until his death.

On the outbreak of the Second Afghan War in November, 1878, "Buster" Browne, then a Lieut.-Colonel, became Political Officer with General Stewart's force in the advance from Quetta to Kandahar ; while Major O. B. C. St. John, R.(B.)E., held a similar post with the division, one brigade of which met with disaster at Maiwand in July, 1880.[1] Browne acted in the dual capacity of Political and Commissariat Officer, as his knowledge of the people and country was of great assistance in the collection of supplies. He emerged from the Afghan War with a C.S.I. and, after leave in England and a period of employment in the Public Works Department, accompanied the expeditionary force to Egypt in 1882 as Commanding Royal Engineer and was present at the battle of Tel-el-Kebir.[2] Within a year of his return to India he was chosen to carry out the construction of the Harnai Railway to Quetta, a most difficult task which he completed early in 1887.[3] A K.C.S.I. was his reward for this work, and it was followed by an appointment as Quartermaster-General of the Army in India under Lord Roberts. Browne had little leisure for political work while on Roberts' staff, for there were numerous expeditions against frontier tribes and preparations for mobilization in case of war with Russia ; however, his chance came

[1] See Vol. I, Chapter XIX, pp. 388, 389.
[2] See Vol. I, Chapter XX, p. 402.
[3] See Chapter IX, p. 152.

when, in April, 1892, he accepted the post of Agent-General and Chief Commissioner in Baluchistan in succession to the late Sir Robert Sandeman. He had no great desire to revert to the civil line, and only did so after much urging by the Viceroy, Lord Lansdowne. He considered that he had already changed his employment too often. He wished to gain distinction as a soldier rather than an administrator, and hoped possibly to become Commander-in-Chief in India.

Sir James Browne's first important act as Agent-General was to depose the Khan of Kalat (a state in Baluchistan) in consequence of misconduct—a step which was approved by Lord Lansdowne and his Council. Then came the question of dealing with the westerly tribes, the Mekranis and others, who were in a state of internecine warfare. It soon became apparent that the Government of India had no intention of bringing Mekran, like Kalat, under Browne's sway. His policy, in relation to Kalat, was no longer in favour at Simla and Calcutta; and when, in direct opposition to Browne's views in favour of Sandeman's "forward" policy, a general withdrawal from Mekran was ordered, a wave of depression spread over the Agency. A heavy blow had been dealt to British prestige, and Browne felt it keenly.

The assimilation of the legal administration of British Baluchistan to that of the Punjab, which was begun before Browne assumed charge and was cancelled after his death, was diametrically opposed to his views and caused him an infinity of trouble. Indeed, it embittered the whole of his career in the Baluchistan Agency, especially as the new Governor-General, Lord Elgin, opposed him on this and most of the other serious questions relating to the province. However, though considered by some as a "firebrand," and baulked in many of his aims, Browne was able to effect material improvements in Quetta and other stations. Roads, gardens, plantations and watercourses changed them from deserts into pleasure grounds. The native bazaars were rebuilt or purified; and churches, courts of justice, offices and bungalows were added. Regarded by the inhabitants as a Mulla and a saint, Browne held a privileged position and made full use of it. But his health was failing. Early in June, 1896, he fell seriously ill, grew rapidly worse, and succumbed on the 13th. His death at the early age of 56 years, so near the normal end of a distinguished military and civil career, was mourned by all Baluchistan and deplored by the Government of India. His remains were buried with great pomp at Quetta, and tablets to his memory were erected in Rochester Cathedral and the chapel of Cheltenham College.[1]

[1] A full biography of General Sir James Browne may be found in *The Life and Times of General Sir James Browne, R.E., K.C.S.I., C.B.* (*Buster Browne*), by General J. J. McLeod Innes, V.C., C.B., late R.E. (1905); and memoirs appear in *History of the Corps of Royal Engineers*, by Major-General W. Porter, Vol. III, pp. 375–379; in *Addiscombe. Its Heroes and Men of Note*, by H. M. Vibart, pp. 637–643; and in *The R.E. Journal*, September 1st, 1896.

Although several military engineers on the Indian establishment have served, during the present century, in political posts, very few have done so in India itself. In 1900, Lieut.-Colonel R. H. Jennings, R.E., was Political Agent in Alwar State, and remained for the next nine years in this or similar employment; but the outstanding example of a politically-minded engineer of modern times was Colonel Sir George Sydenham Clarke, who died on February 8th, 1933, as Lord Sydenham of Combe, G.C.S.I., G.C.M.G., G.C.I.E., G.B.E., F.R.S., one of the most able and distinguished officers ever produced by the Corps of Royal Engineers.

Sydenham Clarke joined the Corps in 1868, and from 1871 to 1880 was an instructor at Cooper's Hill College. In 1882 he served with the Egyptian Expedition and, three years later, under Sir Gerald Graham at Suakin. Then, for nearly seven years, he was Secretary of the Colonial Defence Committee at the War Office, becoming an expert in the problems of Imperial Defence and widening his political outlook. His work as Secretary brought him a K.C.M.G. in 1893. After serving in Malta and at Woolwich he was appointed in 1901 to be Governor of Victoria and held this post for more than two years during which he gained valuable administrative experience, as Sir William Denison had done many years before. Colonel Sir George Sydenham Clarke retired from the Army in 1905, while Secretary of the Committee of Imperial Defence, and was then awarded a G.C.M.G. Two years later he was appointed Governor of Bombay, and made a G.C.I.E. When India gained his services as an administrator, the Army, and the general public, lost a military writer of the first order.[1]

Landing in India on October 18th, 1907, when 59 years of age, Sydenham Clarke was soon plunged into strange surroundings in a province torn by the anti-British movement under the leadership of Tilak, a Brahman of Poona. Clarke grappled at once with this problem. Tilak was arrested in June, 1908, and sentenced to six years' rigorous imprisonment. This was a shattering blow to the forces of unrest, but nevertheless it was deprecated by Lord Morley, the Secretary of State. It is certain that Clarke's strong action in the Bombay Presidency had a beneficial effect throughout the country. "My first two years in India," he writes, "covered the most trying, but also the most educative, period in my whole life."[2] During the autumn of 1909 the finishing touches were given to the Morley-Minto Reforms,[3] with which Clarke was in complete sympathy and which he tried to interpret as liberally as possible. He educated his

[1] Sir George Sydenham Clarke's principal publications were *Plevna*; *Fortification: Past, Present and Future*; *The Last Great Naval War*; *The Navy and the Nation*; *Imperial Defence*; *My Working Life* (1927), and *Studies of an Imperialist*. He also contributed military articles to *The Times* and other newspapers.

[2] *My Working Life*, by Colonel Lord Sydenham of Combe, p. 227.

[3] These measures, leading towards self-government, were discarded in 1918 in favour of the Montagu-Chelmsford Reforms.

Legislative Council in its new duties and responsibilities with some success, but directed his energies with still greater force towards the improvement of scientific and elementary education, in which laudable aim he had the assistance of many rich and influential Indians. He founded a Royal Institute of Science and a College of Commerce in Bombay, and a College of Science in Ahmadabad, and added 2,300 elementary schools.

Like other Governors who were engineers, Sydenham Clarke took the greatest interest in engineering development. In February, 1910, he laid the foundation stone of the massive Lonavla (Lanowli) dam which holds up the Sydenham Lake in the Western Ghats for the supply of electricity to Bombay by the Tata Hydro-Electric Company.[1] He was responsible also for the erection of the marble "Gate of India" on the Apollo Bandar in Bombay. Their Majesties King George V. and Queen Mary landed on that spot on December 2nd, 1910. When they re-embarked on January 10th, 1911, His Majesty asked Sir George whether it would be possible to replace in marble the temporary buildings which had been raised to mark the "Gate of India." Sir George undertook that this should be done; and on March 31st, 1913, a few days before his departure for England[2] as Lord Sydenham of Combe, he had the satisfaction of laying the foundation stone of the fine memorial arch in the Hindu-Saracenic style which is known to every visitor to India.

This description of political and administrative work may fitly close with an extract from Lord Sydenham's writings. "There are pages in the history of our relations with India prior to 1857," he says,[3] "which we may wish to forget; but for more than sixty years our Government can fearlessly be compared with all others in its impartiality and disinterested efforts for the advancement of the masses. History records nothing which can approach the British achievement in India, and the world will never see the like again." Let those so-called Englishmen, who love to decry their country, note these brave words.

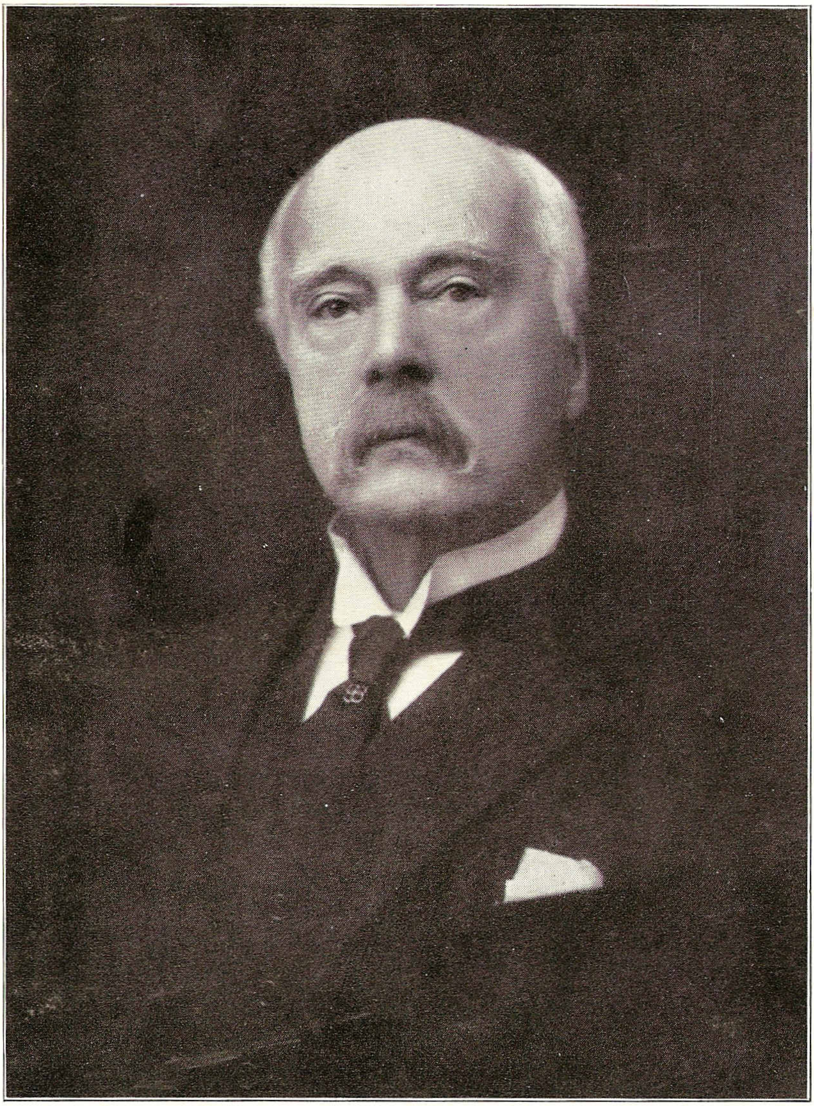
Few military engineers have been attracted to the intricate, hard-working and much maligned financial and accounts branches of the Indian administration. Certain names appear, however, between 1870 and 1900, as Examiners or Controllers of Military Works', Public Works', or Railways' Accounts, and among them those of Lieut.-Colonels R. A. Sargeaunt, A. Davidson, H. D. Love,[4] C. H. P. Christie and C. A. R. Browne; Majors A. J. Filgate, D. H. Traill, L. Conway Gordon, P. Lambert, J. P. Westmorland, H. S. F. Haynes and C. R. Hoskyn; and Captains E. A. Trevor, F. G. Oldham, C. F.

[1] See Chapter III, p. 45.

[2] Lord Sydenham handed over charge on April 4th, 1913, and left Bombay on the following day. A memoir of him appears in *The R.E. Journal*, Vol. XLVII, January–June, 1933, pp. 316–322.

[3] *My Working Life*, by Colonel Lord Sydenham of Combe (1927), p. 292.

[4] See Chapter XVIII, p. 355, for Colonel Love's work as an author and an educationist.



COLONEL LORD SYDENHAM OF COMBE, G.C.S.I., G.C.M.G., G.C.I.E., G.B.E., F.R.S.,
LATE ROYAL ENGINEERS.

Photograph by J. Russell and Sons,
63, *Baker Street, W.*1.

Call and A. G. Begbie. Colonel H. Clarke served as Examiner of Military Works' Accounts from 1894 to 1902; and Colonel E. A. Waller as Examiner of Guaranteed Railway Accounts, and later as Deputy Accountant-General, from 1895 to 1903. Interest centres chiefly on those few military engineers who dealt with the larger questions of finance, and of these the more conspicuous were Lieut.-Generals J. J. McLeod Innes, V.C., and Sir Richard Strachey, and, most eminent of all, General Sir George Chesney.

McLeod Innes was Accountant-General, P.W.D., for no less than ten years (1870–1880), having already gained some financial experience as a Controller of Accounts and as a member of the Commission which investigated the failure of the Bank of Bombay in 1868.[1] His previous military services during the Indian Mutiny are too well known to need recapitulation in these pages.[2] In 1878–79, Richard Strachey, the organizer of the Public Works Department of the Government of India, acted as Finance Member of Council in the absence of his brother, and wrote a highly important minute containing proposals for a reform of the Indian currency which, had they been carried out, would have saved India incalculable loss. Fourteen years later, similar proposals were adopted in consequence of the report of Lord Herschel's Currency Committee, of which Strachey was made a member after he had represented the Indian Government at a Monetary Conference in Brussels.[3]

The third and greatest financial expert, George Tomkins Chesney, was commissioned in the Bengal Engineers in December, 1848, and landed, two years later, in Calcutta. For the first six years of his service, Chesney was employed on civil engineering work. Then came the Indian Mutiny, in which he distinguished himself at the siege of Delhi and was severely wounded in the final assault on September 14th, 1857.[4] When sufficiently recovered, Chesney was posted to Calcutta, where he showed not only engineering ability but the keenest insight into the burning questions of the day. A matter which engrossed his attention most closely was the new financial and economic arrangements necessitated by the removal of the Public Works Department from the control of the Military Board. Under the latter body there had been no proper supervision of accounts or finance; but now, in 1859, a Finance Minister had arrived from England to introduce a budget system and regularize

[1] Memoirs of Lieut.-General J. J. McLeod Innes, V.C., C.B., late R.(B.)E., appear in *History of the Corps of Royal Engineers*, by Major-General W. Porter, Vol. III, pp. 327–330, and in *Addiscombe. Its Heroes and Men of Note*, by H. M. Vibart, pp. 558–562.

[2] See Vol. I, Chapter XVIII, p. 351.

[3] Memoirs of Lieut.-General Sir Richard Strachey, G.C.S.I., F.R.S., LL.D., late R.(B.)E., appear in *History of the Corps of Royal Engineers*, by Major-General W. Porter, Vol. III, pp. 255–258, and in *Addiscombe. Its Heroes and Men of Note*, by H. M. Vibart, pp. 490–495. His portrait, and some remarks on his career, are included in Chapter VIII, "Railway Reminiscences," pp. 123, 124.

[4] See Vol. I, Chapter XVII, pp. 326, 328, 331 and 346.

the finances and accounts of the whole country. On this, Chesney discussed the financial question, so far as it referred to public works, in an article in the *Calcutta Review*, and this led to his being put in charge of the organization of tentative arrangements for keeping the local accounts of expenditure on public works. His proposals proved so successful that, in 1860, he was appointed Chief of the Accounts Branch of the Public Works Department in India, and continued in that post for ten years. The system which he organized enabled the accounts of expenditure to be quickly audited, so that the engineers were freed from anxiety and a watch could be kept on the revenue and expenditure. Chesney's system was soon found to be so satisfactory that the Railway accounts were added to his charge.

Though engaged chiefly on problems of finance and accounts, Chesney lost no opportunity to study other branches of Government work, and as a result was able to publish in 1870 his *Indian Polity*, a compendium on the civil and military services in India, containing suggestions for reform with particular reference to finance. While President of the Royal Indian Engineering College at Cooper's Hill —a part of his career which will be dealt with later—he wrote several other books including *The Battle of Dorking*, *The True Reformer* and *The Dilemma*. These, with *Indian Polity*, showed that he had such a clear grasp of military questions that in 1880 he was selected to be Secretary to the Military Department of India under General T. F. Wilson, and was required to deal, during the next few years, with the arrangements for a projected railway towards Kandahar, an expeditionary force to Egypt, the Third Burma War, several campaigns on the North-West Frontier, and schemes for coast and frontier defence. In 1887 Chesney was appointed Military Member of Council, and held this post until he left India in 1892 with the rank of General. He died on March 31st, 1895, a keen reformer and an eminent authority on every aspect of the military and civil services of India.[1]

For the most part, the political, administrative and financial needs of India are now catered for by civil servants, specialists in their particular lines and efficient to the finger-tips. It is true that ex-regimental officers of the Indian Army are still to be found in these branches; but the Royal Engineer vanished from them before the Great War, never, probably, to return. The Corps must be satisfied with the achievements in the past of Archibald Campbell, Durand, Denison, Browne, Chesney, Sydenham Clarke and others of lower degree. These men helped, by their political insight, or by their ability in administration or finance, to create an India which is the envy of every European nation.

[1] Memoirs of General Sir George Chesney, K.C.B., C.S.I., C.I.E., late R.(B.)E., appear in *History of the Corps of Royal Engineers*, by Major-General W. Porter, Vol. III, pp. 331–334; in *Addiscombe. Its Heroes and Men of Note*, by H. M. Vibart pp. 556–558; and in *The R.E. Journal*, Vol. 25, June 1st, 1895. His portrait appears opposite p. 350.

CHAPTER XVIII.

ENGINEERING EDUCATION.

NO ruling nation has yet created material monuments of its engineering activity in territories across the seas comparable with those of the British in India. Beside them the masterpieces of France and Italy in their African possessions sink into mediocrity. The consolidation of India has been, in no small measure, the work of engineers. Deprived of roads, railways and canals, the country would even now revert to savagery. After British soldiers had dug the foundations in sweat and blood, British engineers raised, as it were, a steel framework for the expansion of the civil administration. It is interesting, accordingly, to investigate the origin of these engineers, and to discover where and how the men were educated and trained who built the Grand Trunk Road, the Ganges Canal, the railway systems and the great bridges of our Eastern sub-continent.

The mistakes and delays which occurred during the fortification of Madras, Bombay and Calcutta show that most of the engineers who were available in India during the seventeenth and eighteenth centuries had little technical training or experience. In the middle of the eighteenth century the East India Company required only a limited number of cadets for their army, and obtained these by appointment both from home and in India. All cadets were posted to the Infantry, and afterwards a few were transferred, sometimes against their will, to the more scientific branches of the Engineers and Artillery. The Directors turned envious eyes on the military school established in July, 1741, at Woolwich, which eventually became the Royal Military Academy and produced efficient officers for the King's Engineers and Artillery. They tried, in 1765, to procure some of these young men for India, but obtained only a few; and in 1786 they stopped the recruitment of their cadets in India, and thus increased their difficulties. So matters continued until 1798, when they were allowed to place a number of lads at Woolwich, and in a college at Marlow, or under private tuition, with a view to replenishing their technical services in India. In 1803 there were 23 Company's cadets at the Royal Military Academy, two at Marlow, and no less than 36 in private academies. Under such a system there could be no equality or co-ordination of training, and the Company had to be content with what it could get.

At length, owing to the insufficient supply of officers for the so-called scientific arms in India, the hostility of the French, and the lessons of the Second Maratha War and the siege of Bhurtpore, the Directors determined to have a Military Academy of their own; and accordingly, in January, 1809, they founded a "Seminary" at Addiscombe, near Croydon, and admitted 60 cadets to this institution for instruction by Dr. James Andrew and a small staff. Eighteen cadets still studied at Woolwich, and seven in private academies. In November, 1815, Addiscombe was thrown open to recruits for the Company's Cavalry and Infantry, in addition to the Engineers and Artillery, and the training became less specialized. Meanwhile, specialization was increasing in the Royal Army, for in April, 1812, a school had been opened at Chatham under Major (afterwards General Sir Charles) Pasley, R.E., for "the instruction of the Corps of Royal Military Artificers, or Sappers and Miners, and the junior officers of the Royal Engineers, in the duties of Sapping and Mining and other Military Field Works."[1] This was the humble beginning of the School of Military Engineering. Although the supply of qualified engineers for both the King's and Company's armies received serious consideration before Waterloo was fought, the men destined for India were trained wholly in England and with little regard to civil engineering.

Addiscombe soon began to produce military engineers for India; but it was not until 1822, when Major H. W. Carmichael-Smyth, late of the Madras Engineers, became head of the Seminary, that military engineers from India began to share in the administration of the institution. Smyth was followed in 1824 by Lieut.-Colonel (afterwards Major-General Sir Robert) Houston, late of the Bengal Cavalry; and Houston, in 1834, by Lieut.-Colonel (afterwards Major-General Sir Ephraim) Stannus, late of the Bombay Infantry, who held the post of Lieutenant-Governor of Addiscombe until his death in October, 1850. Then the administration passed finally into Engineer control. On January 8th, 1851, Lieut.-Colonel (afterwards Major-General Sir Frederick) Abbott, late of the Bengal Engineers, assumed charge, and held it until the college was closed in June, 1861, in consequence of the amalgamation of the Royal and Company's armies.[2] Abbott had distinguished himself, as a subaltern, in the First Burma War,[3] and later in the First Afghan War; and in the First Sikh War he had executed some remarkable feats of bridging. As a sound and experienced engineer, he did much to improve the standard of instruction. Other military engineers, who

[1] *History of the Corps of Royal Engineers*, by Major-General W. Porter, Vol. II, p. 172.

[2] A memoir of Major-General Sir Frederick Abbott, *Kt.*, C.B., late Bengal Engineers, appears in *History of the Corps of Royal Engineers*, Vol. III, pp. 247–251 (by Colonel Sir C. M. Watson). Abbott retired from the army as a Lieut.-Colonel in December, 1847. His subsequent promotions were consequently honorary.

[3] See Vol. I, Chapter XIV, pp. 253, 258.

assisted him on the staff of the Seminary, were Lieutenant T. E. Gahagan, M.E., Captain J. T. Hyde, B.E., Major F. Ditmas, M.E., Captain (afterwards Major-General) W. H. Edgcome, M.E., Captain W. A. Tate, Bo.E., and Captain P. M. Francis, M.E. Thus eight military engineers from the Indian establishment served, at one time or another, at Addiscombe.

During the 52 years of its existence, about 3,600 cadets passed out from Addiscombe, of whom more than 500 were posted to the Bengal, Bombay or Madras Engineers. Most of the engineers who distinguished themselves in peace and war between the first and last campaigns in Burma, came from her portals. Thomson, Cautley of the Artillery, the two Cottons, J. T. Smith, Lord Napier of Magdala, Orr, Baker, Waugh, Durand, the two Cunninghams, Baird Smith, Becher, Yule, Strachey, Lake, Rundall, Crommelin, Michael Kennedy, Alexander Taylor, Dyas, Greathed, J. T. Walker, Sankey, Hutchinson, Chesney, Innes, Ballard, Montgomerie, Trevor, Basevi, Stewart, Goodfellow, Aeneas Perkins, Champain, Prendergast, Thackeray, C. C. Scott-Moncrieff, "Buster" Browne, Pierson, Trotter and Holdich. What a galaxy of talent! And these are a few only of the remarkable men produced by the seminary at Croydon.

Eleven years after the closing of Addiscombe, an institution was founded in England which was administered throughout its career by military engineers from India, though designed originally to train only civil engineers for that country. This was the Royal Indian Engineering College at Cooper's Hill, some 20 miles from London. Up to the Indian Mutiny the engineers needed for the execution of civil works in India were obtained almost entirely from the three Corps of Bengal, Bombay and Madras Engineers, the sole exception being in the case of railways. In 1854 the great railways projected by Lord Dalhousie, who founded the Public Works Department, had been begun, for the most part, by civil engineers sent out from England after nomination by leading men in the engineering profession. Railway construction was checked by the Indian Mutiny; but after the rebellion had subsided, the work was resumed, together with other engineering projects. Irrigation was then being rapidly extended. Telegraph lines were gradually intersecting the peninsula. Military engineers alone could no longer cope with the multifarious duties required by the growing civil administration. Accordingly, in 1858, Lord Stanley, the Secretary of State for India, decreed that a certain number of young men should be selected for engineering service in that country by open competitive examination, and "Stanley's Engineers" thus came into existence. The pay and prospects, however, were not such as to attract capable men in sufficient numbers; so, to reduce the deficiency, short-service engineers were admitted who, unfortunately, proved unsatisfactory.

The Government then decided to build certain railways by State agency; and to execute this project, and at the same time to keep abreast of their work in constructing canals, roads and buildings, they needed 50 recruits annually for their engineering services. The experience of the next few years proved that they could not obtain them. Before 1871 there was no engineering college in Great Britain, though Engineering Departments had been attached to a few colleges in universities. The shortage of trained recruits for India gave rise, during the late " 'sixties," to a growing demand for the foundation of an engineering college in England which would cater for the Indian Public Works Department as the college at Haileybury had done for the Indian Civil Service, and as Sandhurst, Woolwich and Chatham did for the Army in India after the closing of Addiscombe.

It so happened that Lieut.-Colonel (afterwards General Sir George) Chesney, Royal (Bengal) Engineers, was on furlough in England during 1868 and 1869, busily engaged in writing his *Indian Polity*. In his spare moments he devoted much thought to the question of the supply of suitable engineers for India, and eventually came forward with a recommendation for the establishment of a college which should secure for that country a steady influx of engineering talent. He sought the supply at a new source. Civil engineering, like naval and military service, had up to that time run more or less in families. Chesney broke away from tradition and propounded a scheme which found embodiment in the Royal Indian Engineering College at Cooper's Hill. In 1869 this scheme was submitted to the Secretary of State for India (the Duke of Argyll), but was most unfavourably received in certain quarters. Lord Mayo, and his Government in India, were strongly averse from starting a new institution. They had powerful support in Parliament, and also from a few influential military engineers in India who feared the early closure to their brother officers of one of their finest avenues to engineering fame. Nevertheless, Chesney's arguments prevailed. The scheme was sanctioned, and Chesney was appointed as the first President of the proposed institution. He chose a site on the Thames between Windsor and Runnymede, engaged an expert staff, and organized a course of instruction. Widely read, experienced, industrious, clever and sympathetic, Chesney was an ideal President. On August 5th, 1871, Cooper's Hill College came into being, and, in the first three years of its existence, gave India annually the fifty good men whom she needed.

Difficulties then arose. According to the original method, the men who entered Cooper's Hill after a qualifying examination were guaranteed Government appointments if they completed the course satisfactorily; but owing to the cessation of certain public works in India, the number of these appointments was gradually whittled down from fifty to about fifteen a year. The popularity of Cooper's

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LATE ROYAL (BENGAL) ENGINEERS.

Hill began to wane: the entry diminished. The Government of India was faced with heavy expense in maintaining the college, and consequently changed the terms of admission and widened the field of entry. In 1878 students were admitted for training for the Indian Telegraph Department, and, seven years later, for the Forest Department. Chesney, however, did not see the latter innovation, for he handed over charge of Cooper's Hill in 1880 on his appointment as Military Secretary to the Government of India. During his tenure of nine years he supplied 316 qualified engineers to the Public Works Department.

Before Colonel Chesney's departure he was asked to suggest a successor as President, so he wrote to General Sir Alexander Taylor, who had retired and was in England, and asked him if he would like the appointment, and then, being in some doubt as to whether Talyor was not too old for it, went to see him. "On approaching an eminence in the neighbourhood of Surbiton," writes Miss A. C. Taylor,[1] "he saw a stalwart figure and two smaller ones speeding down a slope, each perched on the summit of one of those alarmingly tall and slender wheels which preceded the modern cycle. Suddenly the largest of these machines shot forward and dashed past. The rider steered for a crossing hedge, breasted it, parted company with his machine and landed gracefully on the other side." This was Taylor, 54 years of age, who was being initiated by his boys into the art of riding a "penny-farthing." All doubts as to Taylor's physical fitness having been resolved, Chesney urged him to allow his name to be submitted, but Taylor declined. "I am no schoolmaster," he said. Nevertheless, he ultimately consented, and on November 5th, 1880, he was installed as President of the fine institution which he was destined to administer for the next sixteen years. Assisted as he was by a brilliant civilian staff—Calcott Reilly, Wolstonholme, Unwin, Minchin and others—and by a few selected military engineers, the future held great promise.

Chesney knew, however, that Cooper's Hill College was entering on a crucial phase of its existence. In 1880 the Public Works Department was overstocked with officers and could accept only twenty men instead of fifty. It was necessary to run the college on a reduced income, for it relied solely on fees. The situation had been eased, to some extent, by the admission of telegraph students, and after 1884 it was further improved by admitting forest students, by occasional nominations of men to commissions in the Royal Engineers and other branches of the army, and by supplying engineers to Egypt. Taylor's efforts in these directions were so successful that, from 1887 to 1893, Cooper's Hill was practically self-supporting. Money was earned by testing materials in the mechanical and chemical laboratories of the institution, and no stone was left unturned in praiseworthy attempts

[1] *General Sir Alex Taylor*, by A. C. Taylor, Vol. II, p. 251.

to add to the exchequer. But such expedients could not stave off permanently the attack of wealthy and competing institutions in London, Cambridge, Manchester, Edinburgh, Glasgow and elsewhere. Cooper's Hill College began to decline. Alexander Taylor's administration of it was criticized, and it was said that he lacked the engineering and scholarly knowledge essential for the proper supervision of the work of his technical staff. However, there is no evidence that this was so. Taylor aimed at fostering *esprit de corps* and producing English gentlemen. His professors could add sufficient technical knowledge. India could supply the practical training. The reputation of the Cooper's Hill men, turned out by Taylor and his successors, needs no vindication in these pages. What was lacking in quantity was made up in quality.

Colonel John Pennycuick, C.S.I., late Royal (Madras) Engineers, the hero of the feat of irrigation engineering known as the Periyar Project,[1] followed General Sir Alexander Taylor as President of Cooper's Hill in 1896. Three years later, Pennycuick was succeeded by another irrigation engineer from India in the person of Colonel (afterwards Sir John) Ottley, C.I.E., late Royal Engineers. The end came in 1903. In spite of a most vigorous protest by Lord Curzon and his Government the fiat then went forth that the Royal Indian Engineering College at Cooper's Hill should be closed. For more than thirty years the institution had been a potent factor in raising the standard of all engineering schools. It had trained men for the engineering profession in India as no other British college could do, and it had sent out men of the right stamp. Its career was cut short by competition and financial stress.

In addition to Chesney, Taylor, Pennycuick and Ottley, several other military engineers served at various times on the staff at Cooper's Hill. Colonel (afterwards Major-General) W. H. Edgcome, late Royal (Madras) Engineers, was there from 1871 to 1885; Captain E. H. Courtney, R.E., joined the staff with Edgcome and remained till he left it as a Major-General in 1897; Lieutenant George Sydenham Clarke, R.E. (afterwards Lord Sydenham of Combe) was appointed in 1871 as Instructor in Practical Geometry and Engineering Drawing, and stayed for nine years; Lieutenant T. J. W. Prendergast, R.E., was on the staff during 1885 and 1886; Captain James Stewart, R.E., from 1888 to 1894; and Lieutenant F. M. Browne, R.E., during 1902 and 1903. From 1880 onwards Government maintained a Board of Visitors to inspect the institution and advise on its management, and three military engineers—Lieut.-General Sir Richard Strachey, and Colonels Henry Yule and Sir William Bisset, all experts on Indian affairs—served on it. Thus it will be seen that military engineers, some of whom came from the Indian establishment, were partly responsible for the considerable

[1] See Chapter II, pp. 28, 29.

measure of success which attended the Royal Indian Engineering College at Cooper's Hill.

During the nineteenth century, the engineering needs of India could never have been satisfied solely by recruitment from England, nor would such a system have been desirable. After the Mysore and Maratha Wars and the annexation of the Punjab, an increasing number of British and Anglo-Indians, and a certain proportion of Indians, sought openings in Government service for themselves and their sons. Officers of the Company's Infantry, with little prospect of service in the field, wished to qualify as engineers; and non-commissioned officers of British units hoped to become their subordinates in engineering employment. The experiences of the Indian Mutiny showed the desirability of maintaining in the Public Works Department a stiffening of military men, provided that these could be trained cheaply and adequately by military engineers from Addiscombe and Chatham. It was necessary, also, to encourage Indian talent, and to meet the boom in engineering which followed the troubles of 1857. So India began to found her engineering colleges and to expand the few institutions which existed before the rebellion. To-day she has the celebrated Thomason Civil Engineering College at Roorkee in the United Provinces, serving those provinces and also the Punjab and other northern territories; the College of Engineering at Poona in the Bombay Presidency; the Madras College of Engineering at Madras; the Sibpur Engineering College near Calcutta; and colleges at Patna and Benares. Even Burma has her engineering college, founded about six years ago in Rangoon, through the munificence of the Burma Oil Company. All these institutions, except the Thomason College, are affiliated to local Universities and grant degrees in engineering. Indians have flocked to this profession. The tree has outgrown the garden, and the country now suffers from a glut of engineers with Indian qualifications. But it was otherwise in the nineteenth century, and it is with that period that this narrative must chiefly deal, for the military engineers of India have now handed over their duties in engineering education to the civil servants of Government or to the Universities.

The first of India's professional schools was established in Madras on May 17th, 1794. This was a Surveying School started by Mr. Michael Topping, the Government Astronomer,[1] who chose eight boys from a school in Fort St. George, after failing to get them from the local "Military Male Asylum," and proceeded to train them in surveying. After Topping's death in 1796, Mr. John Goldingham, his successor as Astronomer, carried on the instruction, and the boys soon proved their value. They helped Major Lambton, and Captain Colin Mackenzie of the Madras Engineers, in surveying Mysore, and assisted in marking the new boundary. Two of them accompanied

[1] See Chapter XI, pp. 189, 190.

an early mission to Persia, and another sailed with Sir John Abercromby to Mauritius in 1810, equipped, it is said, with "a double set of linen clothes." A few years later the school was placed under the Civil Engineer's Department of the Board of Revenue; and until 1846, when British non-commissioned officers of the Madras Sappers and Miners were first appointed as Overseers, the Revenue Surveyors trained in the Surveying School were the only class of Upper Subordinates in the Engineering Department, which ultimately became the Public Works Department. However, it had been recognized in 1842 that the Surveying School was inadequate for the proper supply of subordinates, and it was then proposed to establish a "College of Engineers" in the so-called Madras University, to produce not only subordinates but civil engineer officers recruited from among the British officers of the Madras Infantry. Although the proposal met with little encouragement at the time, it was revived in 1847 after the Thomason College had been founded at Roorkee. Meanwhile a certain Major John Maitland, of the Madras Artillery, had started a school for Ordnance Artificers in the Madras Gun Carriage Factory, and the success of this venture during the next few years helped to bring about the foundation of a proper engineering college.

On September 15th, 1857, Lieutenant G. V. Winscom, M.E., was appointed Principal of the projected institution in Madras and proceeded to Calcutta in December to examine the system followed in a Civil Engineering College which had been opened in Fort William in 1856 under Lieutenant (afterwards General Sir) E. C. Sparshott Williams, B.E., after his return from Burma.[1] There is little to record about this Fort William College. Williams remained as Principal until he was invalided in 1859, when he was succeeded by 2nd-Captain (afterwards General Sir George) Chesney, B.E. On his return to India in 1860, Williams was transferred to the Thomason College at Roorkee. The Fort William institution closed on November 7th, 1864, when the training of engineers was undertaken by the Presidency College in Calcutta.

Winscom returned to Madras, and having secured the use of a portion of the palace of the late Nawab of the Carnatic, opened the Madras Civil Engineering College on August 1st, 1859, with a small staff, 26 civilian students, and 20 military students, though none of these was of the officer class.[2] Captain John Carpendale, M.E., who had fought in the Second Burma War,[3] succeeded him in 1860, and was followed in 1863 by Captain (afterwards Major-General) W. H. Edgcome, R.(M.)E., who had been an instructor at Addiscombe in 1861. Edgcome went on furlough to England in 1871, and while

[1] See Vol. I, Chapter XVI, p. 308.

[2] Commissioned officers were trained only from 1862 to 1871; but non-commissioned officers were trained from 1859 until 1923–24.

[3] See Vol. I, Chapter XVI, p. 308.

there was posted as Professor of Surveying at Cooper's Hill. The next in the line of principals was Major (afterwards Major-General) H. T. Rogers, R.(M.)E.,[1] who was confirmed in his appointment in 1873, after officiating for Edgcome. His tenure of seven years' duration was prosperous and happy, and the College became a flourishing concern, turning out qualified civilian engineers, military and civilian overseers, draftsmen and surveyors, after a two years' course of instruction.

But perhaps the most notable year in the history of the Madras Civil Engineering College[2] was 1880, for not only did it herald the beginning of an elaborate extension and reorganization, but it marked the appointment of Lieutenant Henry Davison Love, R.E., as Principal. Love devoted the remainder of his service to the College, which he ruled and guided for the unprecedented period of 27 years. He was largely responsible for its reorganization, including a lengthening of the course, and he succeeded in bringing it up to the most approved standards of his day. A keen mathematician and a sound engineer, Love was also a prolific writer on technical subjects; but he is best known as the author of that monumental, yet entertaining, work, *Vestiges of Old Madras*, whose three volumes (and index) lead the reader through the entire history of Fort St. George during the seventeenth and eighteenth centuries. Popular alike with his staff and students, he presided over the institution until he retired as a Colonel in 1907. He was the last military engineer to serve in the Madras College of Engineering,[3] and with his departure this sketch of its still prosperous career may be brought to a close.[4]

We turn now to the Bombay Presidency in which, encouraged by the success of the Thomason College at Roorkee and the Maitland School at Madras, the Government of India decided in 1854, on the suggestion of the Bombay Government, to found a college for the instruction of civil engineers, surveyors, overseers, foremen and artisans. However, nothing came of this project beyond the starting of an "Engineering Class and Mechanical School" in Poona under the general supervision of Lieut.-Colonel (afterwards General) Walter Scott, of the Bombay Engineers, who was at that time a Superintending Engineer in the Public Works Department. A fresh proposal was submitted to the Government of India in April, 1857, and in 1859, the "Engineering Class and Mechanical School" developed into the Poona College of Engineering with Captain J. B. G.

[1] See Vol. I, Chapter XVI, p. 308.

[2] Renamed the "Madras College of Engineering" in 1886.

[3] Captain C. B. Henderson, R.E., officiated as Principal during Captain H. D. Love's absence in 1887–89, and Major A. W. Smart, R.E., in 1894–95.

[4] The civilian Principals who succeeded Colonel H. D. Love were Messrs W. H. James (1907–22), C. L. Cartwright (1922–25) and M. R. Ry. G. Nagaratnam Ayyar (1925) in office. Other civilians acted for short periods at various times.

Close, Bo.E., an Executive Engineer in the Public Works Department, as Principal.[1]

The Government of India had expressly stipulated that too much importance was not to be attached to training military officers in the Poona College. It was intended that the institution should concentrate on the instruction of Indians, and also of civilians from the domiciled European and Anglo-Indian communities. This procedure did not appeal to Close, who naturally hoped that the College would be maintained for the benefit of soldiers as much as civilians, and that it would be placed under the control of the Chief Engineer. "My ambition," he wrote, "is to render the School available for the instruction of all the European Sappers that come to the Presidency." This raised a protest from the Education Department. "I deprecate the policy which Captain Close recommends," remarked the Director of Public Instruction. "I do not think that the school should be made a mere nursery for Sappers and Miners and the Public Works Department. It trains officers for Government service, but it does nothing for the public." The Director gained his point. The College remained under the control of the Education Department and was affiliated in due course to the Bombay University. No military officers, and few non-commissioned officers, were ever trained within its precincts.

The names of only three military engineers appear in the list of the eleven principals of the Poona College of Engineering since the beginning of the Indian Mutiny.[2] Captain J. B. G. Close, Bo.E., who ruled during that critical period, was succeeded in 1859 by Captain (afterwards General) H. St. C. Wilkins, Bo.E., the designer of the Bombay Secretariat, who remained for five years; and from 1903 to 1911, Major W. V. Scudamore, R.E., was Principal. It is evident, therefore, that the present prosperity and efficiency of the institution in Poona are chiefly the results of civilian endeavour; but some credit should be accorded to Close and Wilkins, who established it on a sure foundation, and also to Scudamore, who kept it in touch with the colleges administered by officers of his Corps in Roorkee and Madras.

Regular officers of the Royal Engineers have never served on the staffs of the civil engineering colleges at Benares, Patna and Rangoon; and the same remark applies to the well-known institution at Sibpur, which was established in 1880 in the old Bishop's College buildings erected sixty years before on the right bank of the Hugli

[1] In 1854 the Engineering Class and Mechanical School at Poona were under the Rev. James McDougall; and afterwards, until 1857, under Mr. Henry Coke.

[2] In 1880 the institution was renamed the "College of Science," but it is now the "College of Engineering." The list of Principals is as follows:—Captain J. B. G. Close, Bo.E. (1857–59); Captain H. St. C. Wilkins, Bo.E. (1859–65); Mr. T. Cooke (1865–93); Mr. S. Cooke (1893–99); Mr. H. F. Beale; Mr. F. L. Sprott; Major W. V. Scudamore, R.E. (1903–11); Dr. H. N. Allen (1911–21); Mr. R. S. Cree Brown (1921–22); Mr. W. L. C. Trench (1922–27); and Colonel C. Graham Smith (1927) in office.

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below Calcutta. But in the north-western areas of India, the domains of the soldier, a college was founded before the Indian Mutiny which has been so closely connected with the Corps of Royal Engineers that it may justly be considered as the creation of that Corps. This is the Thomason Civil Engineering College at Roorkee, actually the oldest, and certainly the most celebrated of its kind, in India. The Thomason College owes its birth to the waters of the mighty Ganges. Without that sacred river there would have been no Ganges Canal; and without the canal, no college. The canal was soon brought to maturity through the genius of Cautley. Its offspring, the Thomason College, fathered by an energetic Lieutenant-Governor, and nurtured by men of wisdom and foresight, grew slowly from the humblest beginnings till it reached its prime in the happy days which preceded the financial crisis of 1930.

The establishment of an engineering college at Roorkee was suggested in 1846 by Lieut.-Colonel (afterwards Colonel Sir Proby) Cautley, of the Bengal Artillery, the famous designer and builder of the Ganges Canal. Cautley was then on furlough, and Major (afterwards Lieut.-General Sir William) Baker, of the Bengal Engineers, was carrying on the construction of the headworks of the canal at Hardwar, some 20 miles from Roorkee, a place which lay on the proposed alignment.[1] While it is probable that the immediate needs of the Ganges Canal in engineer officers and subordinates were the main causes of the foundation of a college at Roorkee, it is possible that Government was influenced to some extent by the wider issue of the necessity for the systematic training of engineers for the whole of Northern India. The Eastern and Western Jumna Canals, not far distant from Roorkee, required improvement and repair. In Dehra Dun, Rohilkhand, and the region around Delhi, extensive drainage and irrigation works were in hand or under alteration. Road-construction was progressing rapidly on all sides, and large buildings were rising in many important centres. It was apparent that there existed a demand for skilled control in almost every branch of civil engineering, and to meet this demand there were British officers of the Royal and Bengal Armies, British non-commissioned officers and soldiers, and Indians, all requiring instruction in engineering theory and practice, and the Europeans, in addition, in the native language and the peculiarities of Indian materials and methods of work.

As early as 1845, Lieutenant (afterwards Lieut.-Colonel) Richard Baird Smith, B.E., the Superintendent of the Eastern Jumna Canal, had begun to train a few young Indians at Saharanpur. Two years later, after the First Sikh War, Lord Hardinge, the Governor-General, resolved to push forward the construction of the Ganges Canal, an undertaking beset with exceptional difficulties between Hardwar and

[1] The building of the Ganges Canal is described in Chapter I, pp. 5—10.

Roorkee, in which section works of enormous size were needed to carry the canal under, through, or over, the natural drainage of the country. Evidently the enterprise would tax to the utmost the skill and industry of the people and the resources of the North-West Provinces, and after it was finished the maintenance of the works would necessitate the services of a large engineering staff. Immediate measures were required to provide a constant supply of well-trained and experienced men, and out of this emergency the Thomason College arose.

Roorkee was selected as the site of the proposed institution because it already had workshops, as well as a library and a model-room for the use of irrigation engineers, and was becoming a favourite resort of those who wished to conduct experiments or discuss technical matters. Officers of the Bengal Sappers and Miners also came there from Meerut on duty, or for sport in the Ganges *khadir*. Accordingly Mr. James Thomason, the Lieutenant-Governor of the North-West Provinces, proposed that a college should be founded at Roorkee for the instruction of students in civil engineering, and that it should be under the direction of the Education Department of the local Government. The scheme met with the cordial support of the Governor-General, and on October 19th, 1847, a small college was opened under Lieutenant Robert Maclagan, of the Bengal Engineers, assisted by a headmaster, a drawing-master, and two Indian teachers. The classes were designed to be three in number : one for training civilians as sub-assistant civil engineers, another for the instruction of British non-commissioned officers and soldiers as overseers, and a third for training Indians as surveyors.[1] It was intended that eight candidates of the engineer class, ten of the overseer class, and sixteen of the surveying class should be admitted annually by means of qualifying examinations, and that those who successfully completed a short course of instruction should receive certificates of proficiency.

However, when Maclagan came to Roorkee in October, 1847, to take over his new duties, he found neither college nor students ; and it was not until January 1st, 1848, that the first students were admitted by the transfer of a few young Indians who were being instructed by Major W. E. Baker, B.E., then officiating for Colonel Cautley as Director of the Ganges Canal. A batch of non-commissioned officers and soldiers arrived in August, and began their studies in tents as no other shelter was available. Meanwhile Maclagan was constructing a small bungalow consisting of two class-rooms, an office, a hall and four verandah-rooms, and was able to move his staff and students into this building before the winter. The site of the first Roorkee College is uncertain, but possibly it may

[1] Article entitled " The Thomason College, Roorkee," by Lieut.-Colonel E. W. C. Sandes, D.S.O., M.C., R.E., appearing in *The R.E. Journal*, Vol. XXXIX, June–December, 1925, pp. 540–548.

GENERAL ROBERT MACLAGAN, LATE ROYAL (BENGAL) ENGINEERS

As an LL.D., Edinburgh University.

have been where the Principal's bungalow now stands. The opening session of Maclagan's college was interrupted by the outbreak of the Second Sikh War, when he and his ten soldier students were absent on field service for two months, or, as it was said, "marched for the frontier."[1] Their military ardour satisfied, they returned and settled down to their textbooks. In 1850 the annual number of British soldiers admitted to the institution was raised to fifteen; and by the middle of the following year there were 50 students of all classes under instruction, and 42 had already passed out into Government service.

The year 1851 marks the birth of the present Thomason College. By that time it had become apparent that the little bungalow was utterly inadequate to meet the exigencies of the situation, so Mr. James Thomason caused a scheme to be prepared for the erection of a new building at a cost of about $1\frac{1}{2}$ lakhs of rupees. He provided also for an increase in the strength of the staff, an expansion of the course of instruction, and the admittance of a larger number of students, including British officers of the Royal and Company's armies who were to form a "Senior Department."[2] The design of the new college was entrusted to Lieutenant George Price, of the 1st Bengal Fusiliers, then employed on the Ganges Canal and destined to become Chief Engineer of Hyderabad, and there is reason to believe that Price supervised the work of construction which began in 1852. It is indeed surprising that a junior officer of the infantry should have been capable of designing and building the noble edifice in the Renaissance style which looks across the plains towards the snowy range of the Himalayas.

he was trained as an Engineer.

Those responsible for the selection of the site of the college showed remarkable judgment. They acquired an estate of 365 acres of fertile land and placed the college, facing north, on the crest of a gentle slope. Within a few miles were some of the greatest irrigation works in the world. The climate was healthy: the water-supply ample. By 1854 the construction of the college and its outbuildings was well advanced, and the Directors of the East India Company decreed that the institution should be known as the "Thomason College of Civil Engineering" in memory of the late Lieutenant-Governor who was responsible for its foundation.[3] In 1856 the construction was finished, and the buildings were taken into use. The Thomason College came unscathed through the rebellion of 1857, and is still one of the finest examples of British architecture to be found in Northern India. Happily Maclagan was able to see this embodiment of his dreams before he relinquished his appointment,

[1] Under orders from Government, Maclagan led a corps of native *beldars* (diggers) to the theatre of war. Fortunately, these coolies never encountered the Sikh warriors.

[2] Forty-six British officers qualified as Assistant Engineers between 1854 and 1874. of these 34 belonged to the Infantry, eight to the Artillery, and four to the Cavalry. Among the Infantry officers in 1864 was Lieutenant F. D. M. Brown, V.C., 1st Bengal Fusiliers, who afterwards became Principal.

[3] The institution is now known as the Thomason Civil Engineering College.

after 13 years as Principal, to occupy a still more responsible post in the Punjab.

The career of General Robert Maclagan is worthy of record, not only on account of his work at Roorkee as the first Principal of the Thomason College, but for his achievements in later years. As a youngster he won almost every prize at Addiscombe, and gaining a commission in the Bengal Engineers at the end of 1839 joined the Bengal Sappers and Miners at Delhi, in March, 1842. During the following autumn he was with the " Army of Reserve " at Ferozepore, when Lord Ellenborough welcomed the victorious troops returning from Afghanistan, and afterwards he was employed in roadmaking in the Himalayas. Having been posted in May, 1843, to the Delhi Canals under Captain W. E. Baker, B.E., he accompanied the latter in August to the dry and thirsty region of Sind ; and when the First Sikh War broke out in December, 1845, he marched towards Ferozepore, and thence to Lahore with that eccentric commander, Major-General Sir Charles Napier. While the " Army of the Sutlej," under General Sir Hugh Gough, was fighting at Mudki and Ferozeshah,[1] Maclagan was placed in charge of the defences of Lahore and received some characteristic advice from Sir Charles. " Take my word for it, Maclagan," said he, " you'll have fighting here before long. We English are bold and brave in battle and can carry everything before us then ; but we are too easily lulled into a sense of security when the fighting is over. Here you may be in peace and quiet without a thought of danger ; enjoying all your comforts—take a glass of beer—and all that sort of thing, and the blow may come down like a sledge-hammer. The only way to be prepared is to keep every man drilled at his proper post, and to have constant examination of the state of your defences. I can't be talking in this way to Colonel ——, an officer of rank and experience. He would only put his tongue in his cheek. But I do to you. You are young and may be guided by experience." The advice was sound, and Maclagan carried out his duties in a most thorough manner, though disappointed, no doubt, that the predicted attack never came. After a period of sick leave at Simla he heard in September, 1847, that he had been selected to be Principal of the College at Roorkee, and except during the Indian Mutiny, he saw no more military service.

In 1852, when the building of the present Thomason College had begun, Maclagan proceeded on furlough to England, his place at Roorkee being taken by Captain J. R. Oldfield, B.E., who officiated as Principal for nearly four years. Maclagan had been deputed to visit the United States to study the American systems of education, and did not resume his duties at Roorkee until the beginning of 1856. Although the routine of the Thomason College went on as usual, it was interrupted in May, 1857, by the Indian Mutiny and could not

[1] See Vol. I, Chapter XVI, p. 293.

be resumed until the following September. Maclagan, and his European staff and students in Roorkee, took a prominent part in the various measures adopted by the gallant Baird Smith for the protection of the British community, who were concentrated in the fortified enclosure of the Canal Foundry Workshops on the left bank of the Ganges Canal.[1] Here a son was born to Maclagan, and a daughter to Baird Smith. The thirty military students of the Thomason College formed the nucleus of the defence. On May 19th, five days after the Workshops were occupied, Baird Smith heard that many men of the Sappers and Miners had left their lines in Roorkee to join the mutineers in other places, so he despatched a small party under Maclagan to investigate the situation and, if possible, to clear the lines. This dangerous mission was executed with great bravery and Maclagan was able to report that the lines were almost empty. Thereafter he wiled away the burning days of June, and the dreary weeks of July and August, in the production of a small journal which he called *The Roorkee Garrison Gazette.* This, however, was not the sum of his labours. "His grand services, his resolution, his sleepless care for all, and his special tender care for all who were left most lonely, are hardly to be described," writes Mrs. Baird Smith. "There must be many with readier tongues than mine who might convey some idea of what he was in that time of sore distress." When Baird Smith left for Delhi on June 27th to take up the appointment of Chief Engineer, an added responsibility fell on Maclagan. It need only be said that he rose nobly to the occasion.

The capture of Delhi on September 14th having restored tranquility in Roorkee and the surrounding districts, the Thomason College resumed its peaceful routine until the end of 1860 when, shortly before his promotion to the rank of Lieut.-Colonel, Maclagan was offered and accepted the appointment of Chief Engineer of the Public Works Department in the Punjab, which he held, with intervals of furlough, until he retired as a General in December, 1878. During these eighteen years the Public Works Department in the northern province was much altered, and many important works were completed. The Irrigation, Railway, and Military Works Branches of the Department were separated from the Buildings and Roads Branch, which alone remained in Maclagan's charge. The Western Jumna and Bari Doab Canals were improved. Work was begun on the Sirhind and Swat River Canals. Railways were introduced, a section of the Grand Trunk Road was built, and many large buildings and bridges were constructed. The Punjab prospered while Maclagan assisted in the direction of its great engineering undertakings. Popular alike with Europeans and Indians, his influence was felt from end to end of that vast territory. After his retirement he became an active member of various scientific, literary

[1] See Vol. I, Chapter XVII, pp. 321, 322.

and religious societies, and in 1890, four years before his death, received the honorary degree of LL.D. from the University of Edinburgh. "It is rare," remarked a writer in the *Guardian*, "that such a combination of clear, accurate thought, balanced judgment and large-hearted sympathy is found in one man; and modesty is hardly an adequate term for the profound Christian humility which characterized all he said and did." The Thomason College was fortunate indeed to have had such a man to guide its early footsteps into the right path.[1]

From 1847 to 1891, all the Principals at Roorkee were Royal, or Bengal, Engineers. Major Robert Maclagan was succeeded in 1860 by 2nd-Captain (afterwards General Sir) E. C. Sparshott Williams, and he in turn by Major (afterwards Major-General) J. G. Medley (1863–1871), Captain (afterwards Colonel) A. M. Lang (1871–1877), and Major (afterwards Colonel) A. M. Brandreth (1877–1891). A departure from precedent occurred in 1891 through the appointment of Lieut.-Colonel F. D. M. Brown, V.C., who was Principal for one year, and also in the case of his successor, Major (afterwards Lieut.-Colonel) J. Clibborn (1892–1902), both of these officers belonging to the Indian Staff Corps (Indian Army). However, a Royal Engineer was appointed once again in 1902, when Captain E. H. de V. Atkinson (now Lieut.-General Sir Edwin Atkinson, K.C.B., K.B.E., C.M.G., C.I.E., Colonel Commandant R.E.) joined at Roorkee and began a successful administration which lasted until 1915. In the second year of the Great War, Lieut.-Colonel Atkinson returned to England, reverted to military duty, went to France as a Commanding Royal Engineer, rose to be Chief Engineer of a Corps, and in 1918 was Chief Engineer of the 1st Army. During 1920 he was Chief Engineer in Mesopotamia, where, for a time, he commanded a division. From 1921 to 1923 he was Director-General of Military Works in India, and then, for a short period, Engineer-in-Chief. Thereafter, from 1924 to 1929, he was Master-General of Supply; and finally, until his retirement in 1930, Master-General of Ordnance in India.[2] General Atkinson's distinguished military career goes far to disprove the contention that long employment in civil duties must necessarily impair an engineer officer's fitness for war.

In 1916, for the first time, a civilian was appointed as Principal of the Thomason College, the selected officer being Mr. W. G. Wood, C.S.I., a retired Chief Engineer of the Public Works Department; but when Mr. Wood left in October, 1921, he was succeeded by a Royal Engineer in the person of Major E. W. C. Sandes, D.S.O., M.C.,

[1] A memoir of General Robert Maclagan, LL.D., late Royal (Bengal) Engineers, appears in *The R.E. Journal* of July, 1894. General Maclagan was the father of the late Colonel R. S. Maclagan, C.B., C.I.E., late R.E., who served in many campaigns on the N.W. Frontier between 1888 and 1898, and of Sir Edward D. Maclagan, K.C.S.I., K.C.I.E., late I.C.S., who was Lieutenant-Governor of the Punjab from 1919 to 1921, and Governor from 1921 to 1924.

[2] See Vol. I, Chapter XXI, p. 430 (footnote), and Chapter XXIV, pp. 518–521.

the author of this volume, who held the post until he proceeded on leave pending retirement in March, 1930.[1] During the 87 years of its existence, eight of the thirteen Principals of the Thomason College have been Royal, or Company's, Engineers, and 32 officers of these Corps have served as Assistant Principals or as Professors.[2] Some of these officers, and a few of the civilian professors, have also officiated as Principal.[3] At one period in its history there were as many as three "Military Assistant Principals" at the College; but normally there was only one, and this post was abolished in 1910 as there was then a large staff of civilian professors. The author joined the College in October, 1910, as Professor of Civil Engineering, and held that post until he was appointed in April, 1915, to command the Bridging Train attached to General Townshend's ill-fated 6th Indian Division in Mesopotamia. After sharing in the rapid advance on Baghdad, the disastrous retreat to Kut-al-Amara, and the long defence of that place—operations which involved the bridging of the Tigris on seventeen occasions—he remained a prisoner-of-war in Turkey until the armistice in 1918 and was unable to rejoin the staff of the Thomason College until February, 1920.[4] Since that date no other Royal Engineer has been appointed to the institution; and it is probable that, with the author's departure in March, 1930, the connection of the Corps with civil engineering education in India was brought to a close.

The annals of the Thomason College make interesting reading, and

[1] Lieut.-Colonel E. W. C. Sandes was succeeded as Principal by Dr. P. P. Phillips, I.E.S. (1931–32), and the latter by Mr. H. J. Amoore, I.S.E., who is now in office.

[2] The military engineers who served as Assistant Principals or Professors were:—Lieutenants J. T. Walker (1852–56), J. R. Monckton (1855), G. T. Chesney (1856 and 1858–59), J. U. Champain (1856–57), W. Jeffreys (1857–58), A. M. Brandreth (1859–61), J. P. Westmorland (1860–63), C. C. Scott-Moncrieff (1861–64), C. H. Luard (1863–64), and James ("Buster") Browne (1864–65); Captain A. J. C. Cunningham (1864–65 and 1870–80); Lieutenants L. Conway Gordon (1865–66), F. Firebrace (1865–68), W. S. S. Bisset (1868–70), C. S. Beauchamp (1869–74), R. R. Pulford (1870–73), F. T. Maxwell (1876), M. H. Gregson (1873–77), and S. M. Maycock (1874–78 and 1879–81); Captains G. C. P. Onslow (1877–78 and 1880–81), R. V. Philpotts (1882, 1883–84 and 1887) and E. Blunt (1886–90); Major J. H. C. Harrison (1877–79, 1881–83, 1884–87 and 1890–93); Lieutenants R. F. G. Bond (1892–95), and H. L. Crosthwait (1893–96); Captains E. D. Bullen (1889–98) and H. B. D. Campbell (1895–1910); Lieutenants W. H. Bunbury (1899–1900, *offg.*), F. R. H. Eustace (1903, *offg.*), T. H. L. Spaight (1907–08, *offg.*), D. K. Edgar (1905–06, 1907 and 1908), and Captain E. W. C. Sandes (1910–15 and 1920–21).

[3] The military engineers who officiated as Principal were:—Captain A. J. C. Cunningham (1876), Lieutenant J. H. C. Harrison (1881 and 1882), Captain E. D. Bullen (1894 and 1897–98), Major W. A. Gale (1898), and Major E. W. C. Sandes (1920 and 1921). The civilian Professors who officiated at various times between 1910 and 1934 were Mr. E. F. Tipple, Dr. P. P. Phillips, Mr. C. J. Veale and Mr. Raja Ram. Messrs. F. W. Sedgwick and H. P. Jordan served for many years as Professors of Electrical and Mechanical Engineering; Messrs. W. L. Stampe, G. Lacey and J. S. Trelawny served as Professors of Civil Engineering; and Mr. B. D. Puri as Professor of Mathematics.

[4] The following publications, by the author of this volume, deal with these operations and adventures: *In Kut and Captivity* (1919), *Tales of Turkey* (1924), and articles entitled "The Adventures of a Bridging Train in Mesopotamia," "The Decision to Defend Kut-el-Amarah," and "The Defence of Kut-el-Amarah," appearing in *The R.E. Journal*, Vol. XXXVIII, 1924, pp. 233, 423 and 545.

sidelights are often thrown on the characters of past principals by the letters of men who have been their pupils. For instance, in writing of the College in 1872, a former European student says: "Our Principal, Major Lang, was very strong and active, and used to play football with us. We played a very rough Rugby game, and he was the neatest 'hacker' I ever saw. In those days I was a heavy forward, weighing over 13 stone and fast, but Lang would hack me off my legs with the greatest ease and precision!" The spirit of keenness which permeated the College was displayed as much in games as in work and helped to establish the reputation of Roorkee as a source of engineering talent.

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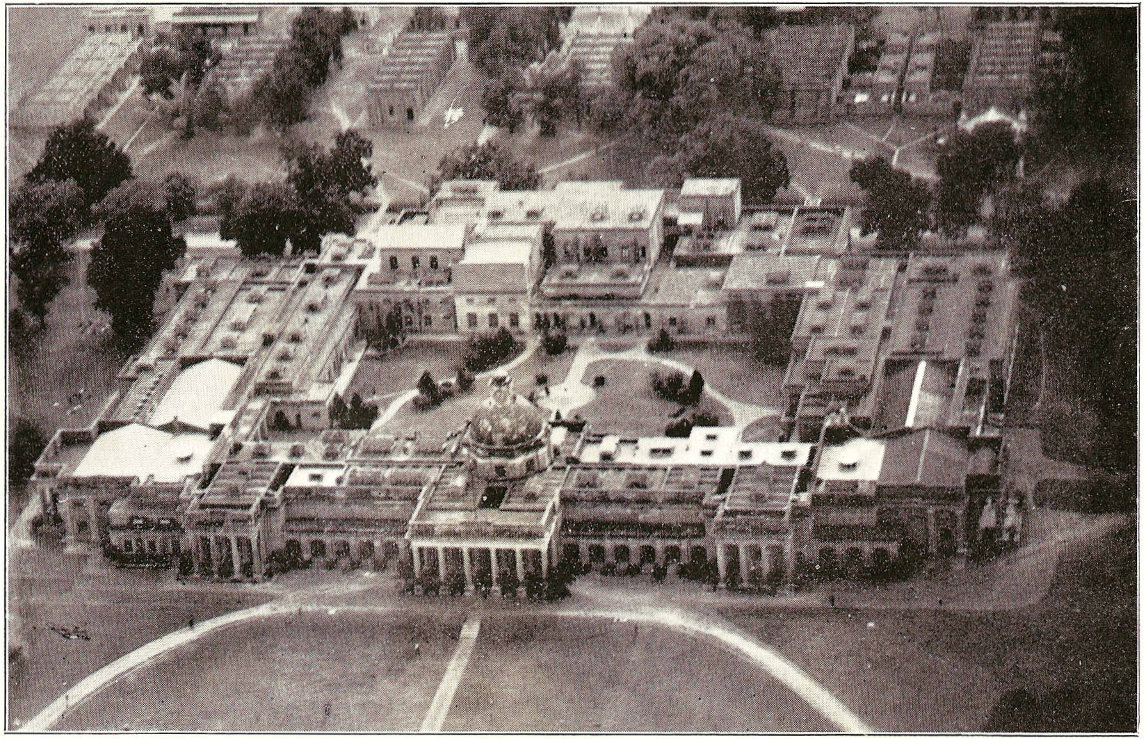
There are now three classes of students at the Thomason College—a civil engineer class undergoing a three years' course of training up to the equivalent of the degree standard in engineering of British universities; an overseer class undergoing a two years' course with a view to qualifying as subordinates; and a draftsman class. Almost all the students are Indians, for the last batch of British non-commissioned officer students left the College in 1924, and there are few candidates from among the European civil community. In 1930 about 200 students were under training, of whom 90 belonged to the civil engineer class. They were taught by a staff of seven professors, who were experienced engineers or graduates of British universities, and by a subordinate staff of British and Indian lecturers and instructors. The Governments of the Punjab, the North-West Frontier Province and other territories, relied on the Thomason College to supply the engineer recruits whom they needed to supplement those obtained from England; and the popularity of the College was such that more than 200 well-educated candidates from Indian universities (many of them graduates of those institutions) sat annually in a competitive entrance examination for 30 vacancies in the civil engineer class. Financial stringency, and the consequent necessity for drastic retrenchment, have now affected the Thomason College as they have every other institution in India. The numbers of the staff and students have diminished, and the prospects of Government employment are not so bright as they used to be; but the students of the present day endeavour to emulate their predecessors, and there is still a demand for civil engineers holding the College diploma. The achievements of past students such as F. R. Bagley, Sir William Willcocks and Sir William Garstin are incentives to the modern product of Roorkee.

The general engineering training given to civil engineer class students at the Thomason College is more theoretical than it was fifty years ago, and resembles, in many respects, the training imparted in the engineering colleges of British universities; but it concentrates more on practical surveying, and less on mechanical and electrical



THOMASON CIVIL ENGINEERING COLLEGE, ROORKEE.

engineering, than is the practice in England.[1] The immediate needs of a country must necessarily decide the nature of the instruction to be given to its engineer students. In England, machinery has ousted manual labour to a greater extent than in India, and consequently more elaborate courses are required in mechanical engineering. On the other hand, the training of engineers in practical surveying is more important in India than in Great Britain, where professional surveyors abound. Hence the time and attention devoted at Roorkee to surveying in all its branches, and the elaborate equipment of the latest patterns of tacheometric levels and theodolites. The series of engineering projects executed by the civil engineer class students during their final year involves several weeks of surveying in the field and designing in the College, and as each student works separately, none but the most practical can pass out high on the list.

The staff and students of the Thomason College have always formed a happy and self-contained little community. Within the quadrangular main building are classrooms, laboratories, offices, a fine library, a convocation hall and ballroom, and model-rooms in which the students may examine at their leisure the details of the latest types of steel bridges and other structures.[2] On the estate are hostels, clubs, bungalows for the Principal and his staff, a mosque, recreation grounds, tennis and squash courts, large workshops, a hospital, a bakery, a dairy and a small bazaar; and farther afield, on the Ganges Canal, a boat-house well supplied with racing and pleasure boats from Oxford. Plentifully fitted with electric lights and fans, with its own water-supply operated by electrically-driven pumps, and situated in one of the best and prettiest stations in India, the Thomason College can bear comparison with any educational institution in the world. It does credit to the energy and industry of its creators, the military engineers of India.

The head of an engineering college is called upon to deal with every branch of engineering; yet his material is more human than concrete. He must be prepared to solve, often at a moment's notice, problems of very diverse natures—technical, educational, administrative and even social—and many are the surprising requests which reach him and his staff. One hot-weather morning the Curator of the Thomason College Book Depot received the following enquiry and applied to the Principal for advice: "To the Curator (Skin). Will you kindly let me know whether there are any arrangements in the College at Roorkee to cleanse Dear Skins as I intend to send the

[1] A comparison of the systems followed in England and India is given in a publication of the U.P. Government in India entitled *Report on Civil Engineering Education in Great Britain*, 1924, by Major E. W. C. Sandes, D.S.O., M.C., R.E., Principal, Thomason College, Roorkee.

[2] The equipment of civil engineering models is described in an article entitled "Engineering Models," by Lieut.-Colonel E. W. C. Sandes, D.S.O., M.C., R.E., appearing in *The R.E. Journal*, Vol. XLII, January–June, 1928, pp. 276–283.

skins for such purification." Fortunately the intention was not carried out. The Principal himself was once asked, "as a piece of purely philanthropic work," to place the following notice in the College corridor: "*Wanted*—Bachelors for my two nieces, aged 17 and 15 years, beautiful, well accomplished, Middle-passed and qualified in Arithmetic, Geography, History, Hindi, Cooking, Needle-work and Laundry work. Know English also. Father a pensman. Desiring youths, about to enter life, may correspond direct." And within a few days came a copy of an advertisement: "*Wanted*—Beautiful, educated girl (*not plum-bodied*), aged about 18, for marriage of highly educated son with over a *lac* yearly income. Family highly flourishing (unencumbered). Needy families of position may apply." Unfortunately the Principal, being no judge of plum-bodied maidens, could not bring the two advertisers into touch, and he was thus denied the pleasure of sharing in a small romance.

Busily engaged with his official correspondence, the author once unfolded a grimy letter which was headed, in bold characters, "Sweet Mercy is Nobility's True Badge." Much intrigued by this novel opening, he read on. "Revered Sir," continued the writer. "Although an unknown and cast-away youth like myself has no claim on your precious time and your patience of mind, I still find no other alternative but to be constrained to take advantage of the generosity of your heart. In the name of God and Sweet Mercy I resign myself entirely and wholeheartedly to your much-heard-of clemency. In vain did I pass the Intermediate Examination in Science of the Calcutta University, for with all my this and other qualifications, if qualifications they be at all, I am in the deepest abyss of darkest despair and ignorance. A regular and well-behaved student, they all predicted, on warrant even, I would make a man of myself in future. I too, Sir, have been feeling, since my boyhood, an impulse for a practical man. But circumstances would not permit me to pursue the aim of my life, and my parents did not hesitate to discard me. Thus became I a helpless and forlorn cast-away, tossed here and there and cast adrift in the vast ocean of mental perplexity and struggle for existence, but with one hope —idolized quietly and secretly at the bottom—that I may yet see brighter hours. Now, my most honoured Sir, would you not take pity on me and admit me in the true worth of large-heartedness into your College, and thus save a youth of 20 from so much hatred, disgrace and oblivion? My last resources for your conviction are my university and character certificates. Hoping to be excused for this intruding botherance, I remain, Yours obediently. . . ."

Unhappily, nothing could be done for this applicant, because he had not the necessary qualifications to enable him to sit for the entrance examination at Roorkee. Entrance to the engineering colleges of India can be gained only by a fortunate minority of

educated Indian youth, and as a result of severe competition. The letter, amusing enough in its choice of words, has its tragic aspect, for it furnishes one of many examples of the desperate straits to which university students are put to find employment in an overcrowded world. It is from such sources that Communists obtain the tools for their subversive designs.

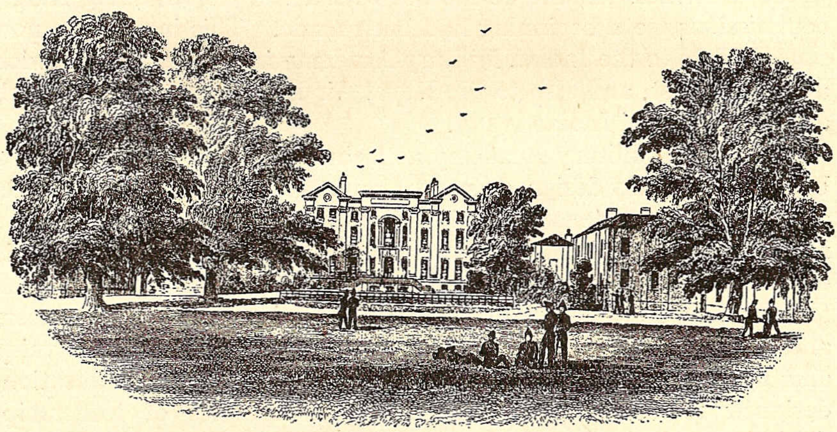
Although the long connection of military engineers with civil engineering education in India seems to have come to an end, an Indian Military Academy, designed to provide King's commissioned officers for all branches of the Indian Army, including the Engineers, has been founded at Dehra Dun and has two Royal Engineers on its staff, Brigadier A. J. G. Bird, D.S.O., being the Assistant Commandant and Major H. Williams one of the Instructors. In 1926 an "Indian Sandhurst Committee" assembled at Delhi under Lieut.-General Sir Andrew Skeen to make recommendations for the establishment of a military college on Indian soil, but nothing came of this project. However, a Prince of Wales' Indian Military College, which had been opened by His Royal Highness at Dehra Dun in March, 1922, for training Indian boys from eleven years of age, was already preparing cadets for Woolwich and Sandhurst with a view to obtaining King's commissions, so a beginning had been made. This institution now sends cadets to the Indian Military Academy instead of to Woolwich and Sandhurst, and also to the Royal Air Force College at Cranwell and to the Royal Indian Navy.

The Indian Military Academy at Dehra Dun was established in a building originally designed as an Indian State Railways Staff College, and certain additions and alterations were made to secure the required accommodation for the staff and cadets. The Academy is divided into a "Woolwich" wing and a "Sandhurst" wing, the former being for cadets who elect for the Indian Artillery, Engineers and Signals, and the latter for those destined for the Indian Cavalry and Infantry. The cadets undergo a course of $2\frac{1}{2}$ years' duration, designed to develop in them the characteristics of leadership, discipline and physical fitness, to imbue them with a high sense of honour and responsibility, and to enable them to perform the essential duties of a junior officer in their selected branch. It is possible that, in the future, Indian 2nd-Lieutenants of the Engineer Corps may join a special class at the Thomason College for a comprehensive course of instruction in civil engineering corresponding with that undergone at Cambridge by young officers of the Royal Engineers; and, if this scheme is sanctioned, it will be greatly to the advantage of the Indian military engineers, and of the Thomason College, which has had so close a connection with the Army.

The history of India shows that engineers of the Royal and Company's Armies have excelled in every field of civil endeavour. Excavating canals, building dams, laying railways and telegraphs

through mountain and jungle, bridging great rivers, erecting buildings and lighthouses, surveying amid Himalayan snows, ruling provinces, delving into archæology, supervising mints, and managing colleges, they have played a leading part in the development of the country. Their exploits in war have been dealt with in another volume, and an endeavour has been made in these pages to describe some of their achievements in peace. Posterity will say of them that their successes have far outweighed their failures, and that, true to their motto "*Quo fas et gloria ducunt,*" they have laboured faithfully and well in those vast territories which form our Indian Empire.

THE END.



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The rank shown against a person is the highest rank mentioned in the book, and not necessarily the highest rank attained by him.

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Nk B L Dixit

Attach Members

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Civil Staff Members

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